Draft Final Report

Development of Merit Order Dispatch Procedures

Public Utilities Commission of Sri Lanka

August 2021

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List of Abbreviations

Abbreviation	Definition
CEB	Ceylon Electricity Board
IPP	Independent Power Producers
NCRE	Non-Conventional Renewable Energy
PPA	Power Purchase Agreement
PSA	Power Sales Agreement
PUCSL	Public Utilities Commission of Sri Lanka
SCADA	Supervisory Control And Data Acquisition
SCC	System Control Center
SDDP	Stochastic Dual Dynamic Programming
SPP	Small Power Producers

1. Introduction

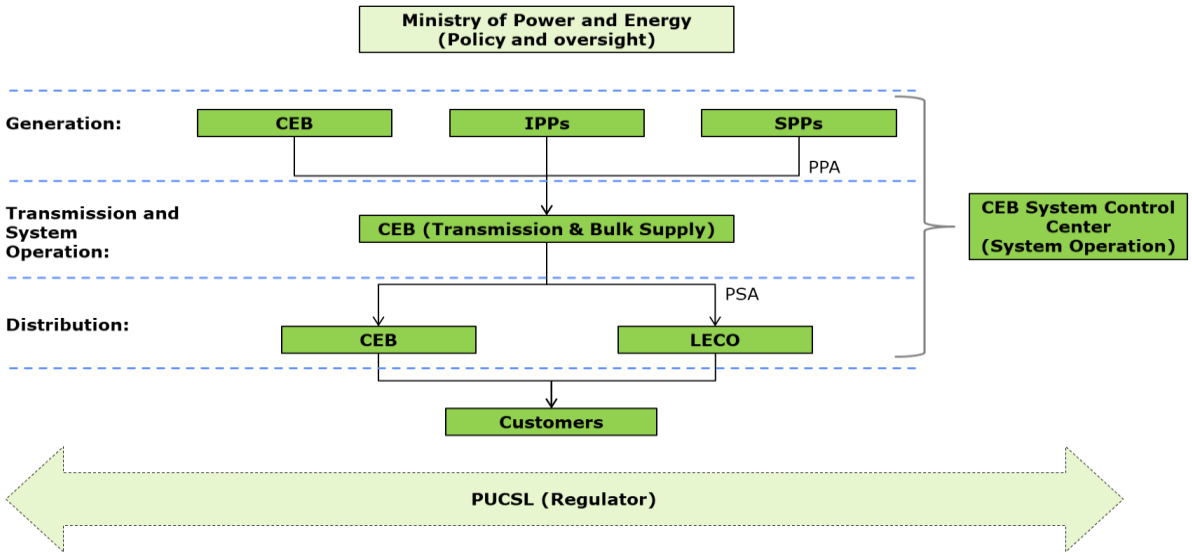
This section sets out the context and background of the assignment.

1.1 Background to the Study

1.1.1 Institutional Structure of Sri Lankan Power Sector

The Ceylon Electricity Board (CEB) is a state-owned corporation established on 1st November 1969 under the Ceylon Electricity Board Act 1969. CEB is an integrated utility that undertakes Generation, Transmission and Distribution of electricity. It is also the single buyer of all the power generated in the country. Apart from CEB, there are IPPs and SPPs that also generate electricity, and LECO (a state-owned entity) that also distributes electricity. The institutional structure of the Sri Lankan Power Sector has been illustrated below:

Figure 1: Institutional Structure of Sri Lankan Power Sector

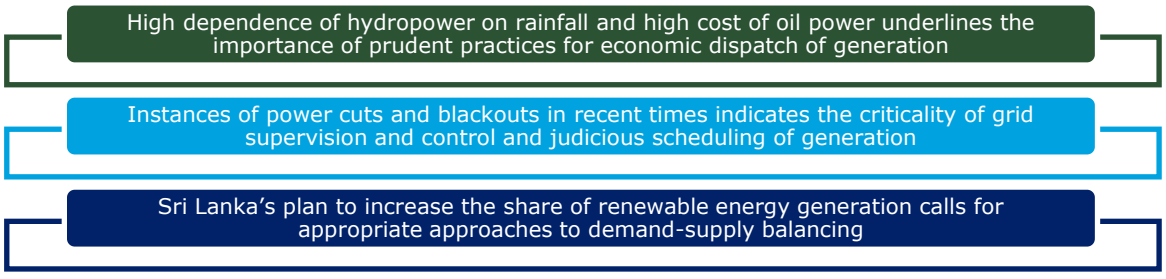


The System Control Center (SCC) has been set up within CEB and functions as the System Operator for the Sri Lankan electricity sector. The SCC is responsible for monitoring of operation of the Sri Lankan electricity grid and optimum scheduling and dispatch of electricity in Sri Lanka with the overall aim of ensuring reliable, secure and efficient grid operation.

1.1.2 Key Challenges of the Sri Lankan Power Sector and Criticality of the Operations of SCC

The Sri Lankan Power Sector is currently witnessing major challenges in terms of high cost of oil power, power cuts and increase in Renewable Energy integration leading to demand supply balance issues.

Figure 2: Key Sri Lankan Power Sector Challenges



Thus, the operations of the System Control Center in managing the dispatch schedules are extremely critical

for the overall sustainability of the sector.

1.1.3 Need for Review of the SCC's existing operating procedures

The Operations of the System Control Center are majorly governed by the provisions of the Grid Code of Sri Lanka, 2014. However, as per PUCSL, the current operating procedures of the SCC require strengthening in the areas of documentation and reporting. PUCSL also intends to review the existing Scheduling and Dispatch Procedures and audit guidelines vis-à-vis the requirements as per the regulations in order to identify the key areas of concern and improvement.

Thus, PUCSL appointed Deloitte Touché Tohmatsu India LLP for assisting in development of the documented procedures for the SCC to improve the operating & audit processes of the SCC

1.2 Objectives of the Study

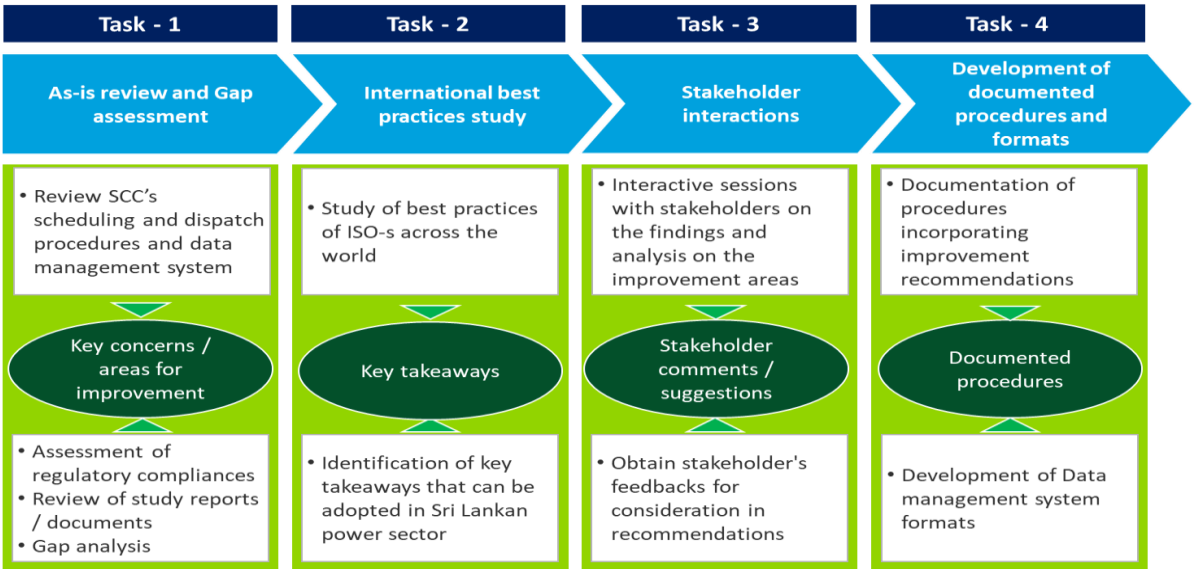
The key objectives of the Study are:

- Review of the existing documented procedures and audit guidelines of the SCC and identify areas of concern and improvements
- Assessment of the compliance in the existing operating process of the SCC vis-à-vis the guiding regulations for SCC
- Establishment of proper documented procedure and audit guidelines at the system control center
- Ensuring that all relevant reliability requirements are satisfied at dispatch planning and grid operation processes
- Conduct a dispatch audit for year 2019 based on the dispatch audit guidelines already issued by the Commission and the developed dispatch procedures (to be completed in 2020).

1.3 Our Approach to the Assignment

Based on the activities undertaken during the Inception Phase and identification of key focus areas, we have designed our overall high level approach for this assignment. The overall approach is represented with the help of the following diagram:

Figure 3: Our Approach to the Assignment



Our approach is broadly divided into four key task namely:

1.3.1 Key Tasks as part of our Planned Approach

1.3.1.1 Task-1: As-is review and Gap assessment to identify key concerns and areas for improvement

As part of our Inception Phase and Report we had reviewed the as-is procedures and reporting practices followed by the System Control Center (SCC) and compared them with the prevailing Regulations and procedures stipulated under the Grid Code. We had also assessed the Dispatch Audit Report for 2017 and have compared them with the SCC's Self-Assessment Report for 2019. Further we had discussions with the PUCSL and CEB officials on the practices followed by SCC which also led to identification of the priority areas for improvement.

1.3.1.2 Task-2: Global case studies

We have also studied the best practices followed by Independent System Operators globally and assessed the prevailing regulations, operational procedures, reporting frameworks. Based on the study, the key takeaways for strengthening the existing practices and functions of the SCC in Sri Lanka have been identified. We presented initial findings, analysis, and recommendations for PUCSL and CEB.

1.3.1.3 Task-3: Stakeholder Discussions & Presentation on Recommendations of Draft Revised procedures

Based on the feedback received from PUCSL and CEB on our findings and options for revision in the process and reporting framework for the SCC, we have drafted the revised operations procedures in line with Grid Code and submitted the same for stakeholder comments.

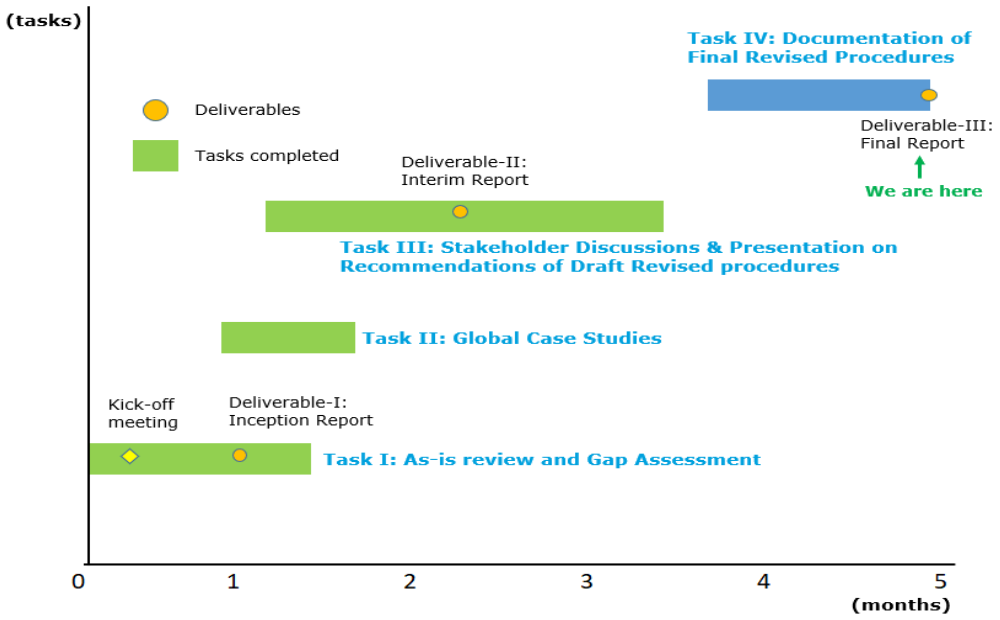
1.3.1.4 Task-4: Documentation of Revised Procedures

Based on the stakeholder comments in Task-3, we have prepared the draft final report incorporating the recommendations from stakeholders on revised procedures. The Final Report would be circulated to PUCSL and CEB officials for wider circulations to the power sector stakeholders.

1.4 Progress till date

The following diagram provides the progress till date for the current assignment:

Figure 4: High Level Work Plan



As part of the **Inception Report**, the following activities were carried out:

- Comparison of As-is Practices vis-à-vis the mandates in the Grid Code
- Comparison of As-Is Reporting / Disclosure practices of SCC vs. those stipulated in Grid Code
- Study of Dispatch Audit Report for 2017 and Current Implementation Status of the Audit Recommendations
- Study of Self-Assessment Report for 2019

As part of the **Interim Report**, the following activities were carried out:

- Detailed Assessment of the Compliance of Documented procedures of SCC vis-a-vis prevailing Regulations and procedures stipulated under the Grid Code.
- Benchmarking of Institutional, Capacity Building and Disclosure practices of SCC vis-a-vis International System Operators and identification of areas where SCC's operations & processes can be strengthened.

The findings from the Interim Report are presented below and comments of CEB has been incorporated to prepare the drat final report.

2. Gap analysis of SCC Documented Operational Procedures, Institutional Structure and Disclosure Practice

2.1 Assessment of Compliance of Documented Operational Procedures of SCC vis-a-vis Grid Code

2.1.1 Comparison of as-is documented procedures with Grid Code provisions

We have studied the provisions available in the Grid Code for the power system management procedures. In Section 4.5 of the Grid Code, the role of the system operator has been highlighted

"The System Operator has the responsibility of system operations planning, including planning of reservoir operations1, forecast of energy balance and identification of generation resources expected to be available to supply the forecast demand with adequate reserve, considering system constraints and meeting the required performance standards."

Based on the documented Operation Procedures of SCC made available to us, we have mapped the documented procedures with those stipulated in the Grid Code. The mapping and compliance status of the same has been assessed below:

Table 1: Assessment of Compliance of Documented Procedures of SCC vis-a-vis Grid Code

Procedure as per Grid Code		Documented Operation Procedure of SCC	Status of Compliance with Grid Code Requirement
Water management and reservoir planning			
Grid Code 4.5.3 – Water management and reservoir planning	• Plan for optimizing the use of the water made available for being administered by the power sector for hydropower generation;	• Based on the weekly Coordination Meeting, decision of hydro plant operations in the coming week is collectively made ensuring irrigation, drinking and power generation requirements are met	Complied (Weekly) *(Ref. SCC document 'Water Management Directives')*
	• Plan for how to use the reservoirs with a storage capacity that allow yearly, seasonal, or monthly regulation of outflows;	• Not clear from procedure document	Not Complied *(Ref. SCC document 'Water Management Directives')*
	• Develop scenarios for hydrology, thermal availability, load forecast;	• As per the Water Management Directives the SDDP Dispatch tool is used as an input for planning week ahead water requirement	Complied *(Ref. SCC document 'Water Management Directives')*
	• Coordinating with the Water Management Secretariat	• Weekly Operational meeting held at the Mahaweli Authority with representatives from Mahaweli authority, Irrigation department, and National Water Board and Ceylon Electricity board.	Complied (Weekly) *(Ref. SCC document 'Water Management Directives')*

Procedure as per Grid Code		Documented Operation Procedure of SCC	Status of Compliance with Grid Code Requirement
Year-ahead Plan			
Grid Code 4.5.4 – Year-ahead Plan	• Develop the Year Ahead Plan using a medium and long term operation planning optimization model to define the economic allocation of hydropower resources made available for power generation and conduct a hydrothermal optimal dispatch	• NCRE forecast from integration of Non-Conventional RE Generation into Sri Lanka Power Grid is used an input • However, it is unclear if Year Ahead plan takes into account the "economic allocation" of hydropower resources.	Not Complied *(Ref. SCC document 'Demand Forecast')*
	• Conduct a hydrothermal optimal dispatch;	• Hydro-thermal optimization and operational analysis carried out with the SDDP tool as discussed in the "Water management and reservoir planning" earlier.	Complied *(Ref. SCC document 'Demand Forecast')*
	• System Operator to Collect information from Licensees related to demand, generation, load forecast, annual maintenance plan, fuel prices and availability, reservoir operation, rainfall forecast, upstream or downstream water restrictions.	• Demand forecast carried out. Annual maintenance plan is prepared to schedule thermal and hydro power plant outages with minimum impact to power generation, irrigation and drinking water releases. Fuel forecast is done to ensure monthly and weekly fuel requirement of CEB & IPP are prepared. • For reservoir operation, rainfall forecast, upstream or downstream water restrictions, the SDDP Tool is used for monthly "Water management and reservoir planning"	Not Complied Few Forecasts are considered on Annual Basis with rest forecasting on Monthly / Weekly Basis
	• System operator to prepare report on energy balance and system operation for the 12 months of the Year Ahead Plan comprising of: i. Load forecasts. ii. Expected energy balance. iii. Indicative generation plan and fuel requirements. iv. Indicative maintenance plans for generation and transmission assets. v. Expected reservoir operations. vi. Expected shortages (or risk of shortages) with an estimation of the energy not served. vii. Expected risks of spilling of water and renewable energy resources.	• Year Ahead Energy forecast is conducted. However, whether the output comprises the Grid Code requirement is not clear	Not Complied *(Ref. SCC document 'Demand Forecast')*
	• No later than 30th day of April and 31st October each year, or any other date specifically stated by PUCSL in years when Tariff Filings	• No information	Not complied *(Ref. SCC document 'Demand Forecast')*

Procedure as per Grid Code		Documented Operation Procedure of SCC	Status of Compliance with Grid Code Requirement
	are scheduled, the System Operator shall prepare the provisional version of the Year Ahead Plan. This version shall be sent to PUCSL for approval.		
	Monthly Updated Plan		
Grid Code 4.5.5 – Monthly Updated Plan	• Adjusting the economic positioning of hydro resources made available for power generation • Obtain an updated hydrothermal optimal dispatch plan • Submission of the Plan to PUCSL and Publication of the Plan	Procedure is explained in detail under SDDP Manual	Complied *(Ref. SDDP User Manual)*
	Week-ahead Plan		
Grid Code 4.5.6 – Week-ahead Plan	• Maintenance requests for the week consistent with the approved annual maintenance plan	• Not available *(No procedure at present as week ahead plan is not prepared)*	Not complied
	• Balance between the available energy resources and the demand for the week,	• Not available *(No procedure at present as week ahead plan is not prepared)*	Not complied
	• Notification to the licensees and Publication of the Plan	• Not available *(No procedure at present as week ahead plan is not prepared)*	Not complied
	Day-ahead Economic Dispatch		
Grid Code 5.6 – Day-ahead Economic Dispatch	• Day-ahead Security constrained dispatch model based on the results of the Week Ahead Plan;	• Dispatch schedule prepared for half an hour interval considering inputs from Demand Forecast, O&M Cost, availability, water management directives.	Complied *(Ref. SCC document 'Day Ahead Security Constrained Hydrothermal Generation Scheduling and Dispatch & Publication')*
	• All generators must be dispatched with the spinning reserve required to meet the performance standards established in the Grid Code, except in conditions of supply deficit or operational restrictions. In such emergencies, the System Operator may choose to operate with a lower reserve margin. This situation needs to be immediately informed to PUCSL and the Licensees	• Not Available	Not Complied *(Ref. SCC document 'Day Ahead Security Constrained Hydrothermal Generation Scheduling and Dispatch & Publication')*

Procedure as per Grid Code		Documented Operation Procedure of SCC	Status of Compliance with Grid Code Requirement
	in the most practicable manner.		
	• Notification to Generators and Distribution Licensees about the dispatch plan	• Not Available	Not Complied *(Ref. SCC document 'Day Ahead Security Constrained Hydrothermal Generation Scheduling and Dispatch & Publication')*
Administration of Shortages			
Grid Code 5.7- Administration of Shortages	• Planning and instructing Licensee to shed load if the Day Ahead Dispatch or Real Time Dispatch show shortage of energy in the system as a whole or in one or more specific regions in the system, owing to insufficient generation or insufficient transmission capacity.	• As per the Load curtailment allocation for energy shortage procedure document, a predefined power cut schedule is prepared for different time slots according to lack of generation to maintain demand supply balance.	Complied *(Ref. SCC document 'Load curtailment allocation for energy shortage')*
Real-time Operation and Dispatch Instructions			
Grid Code 5.8 – Real-time Operation and Dispatch Instructions	• The System Operator shall follow the generation and reserve scheduled on the Day Ahead Economic Dispatch, except when conditions require an update of the economic dispatch and re scheduling of generation and/or reserves. Normal deviations of the load will be covered using spinning reserve Ancillary Services.	• No information on deviations being controlled through spinning reserves	Not Complied *(Ref. SCC document 'Generation dispatch & Frequency Control')*
	• Review forecast and actual system conditions, including load, generation availability and constraints, and update the expected conditions for the rest of the day.	• Generation dispatch and frequency control is carried out to ensure system frequency is within safe operating limits. • Voltage control on transmission system is done to ensure end user voltage is within safe operating limits.	Complied *(Ref. SCC documents 'Generation dispatch & Frequency Control', 'Voltage Control on the Transmission System')*
	• Modify/ re-schedule the generation when a Generation Licensee informs a modification in the availability.		Complied *(Ref. SCC document 'Generation dispatch & Frequency Control')*
Operations Report and Ex-Post-Dispatch Analysis			
Grid Code 5.9 – Operations Report and Ex-Post-Dispatch Analysis	Publication and Submission (to PUCSL) on daily basis of an Operations Report containing an evaluation of deviations between actual conditions and conditions that were expected in	• System Operator Information Publication- to bring CEB higher management up to date on daily system operations and major issues.	Not complied (Monthly and Yearly reporting carried out to CEB Management with no mention of

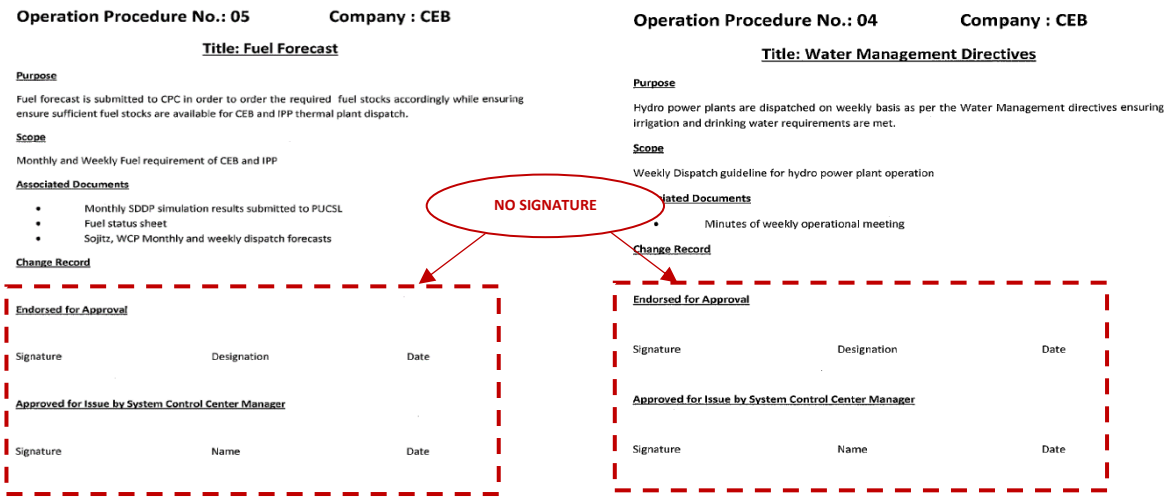
Procedure as per Grid Code	Documented Operation Procedure of SCC	Status of Compliance with Grid Code Requirement
the day ahead dispatch, and how such deviations affected generation scheduling, operational economics, reserve, and the quality of service.	• Monthly review report- summarizes monthly energy, costs system losses, reservoir performance and equipment outages. • Annual Operations Report- highlights all relevant data for CEB higher management on annual basis.	reporting being done to PUCSL) *(Ref. SCC documents 'System Operator Information Publication', 'Monthly review report' and 'Annual Operations Report')*
Additional documented Operation Procedures of SCC:		
Merit Order- Used for economic dispatch of thermal power plants. Scope – Monthly thermal plant merit order including CEB and IPP plants		Data from Merit Order is used as input into the SDDP tool for Generation dispatch and frequency control

2.1.2 Other Observations

Apart from the above compliance assessment, we also observed that the documented operational procedure documents had the following omissions:

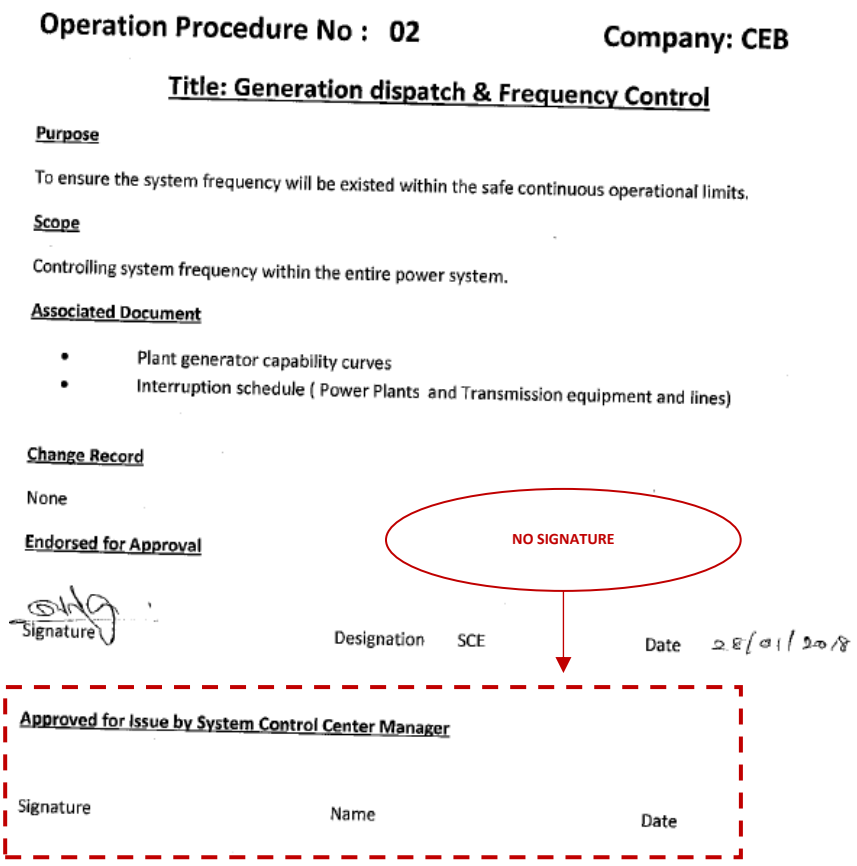
a) **No Signature for Endorsement for Approval as well as Approval for use by System Control Center Manager** – Documented Operational Procedure such as Demand Forecast, Merit Order, Maintenance Plan, Water Management Directive, Fuel Forecast do not have any signature for endorsement / approval for use by SCC. The following snapshot illustrates the Fuel Forecast & Water Management Directive Documented Operational Procedure for SCC and the missing signatures:

Figure 5: Illustration for Missing Signature for Endorsement / Approval for use of Documented Procedure of SCC



b) **No Signature for Approval for use by System Control Center Manager –** Documented Operational Procedure such as Day Ahead Security Constrained Hydrothermal Generation Scheduling and Dispatch & Publication, Generation dispatch & frequency control among others have the signature for endorsement but not the signature for approval for use by SCC. The following snapshot illustrates the Generation dispatch & frequency control Documented Operational Procedure for SCC and the missing signatures:

Figure 6: Illustration for Missing Signature for Approval for use of Documented Procedure of SCC

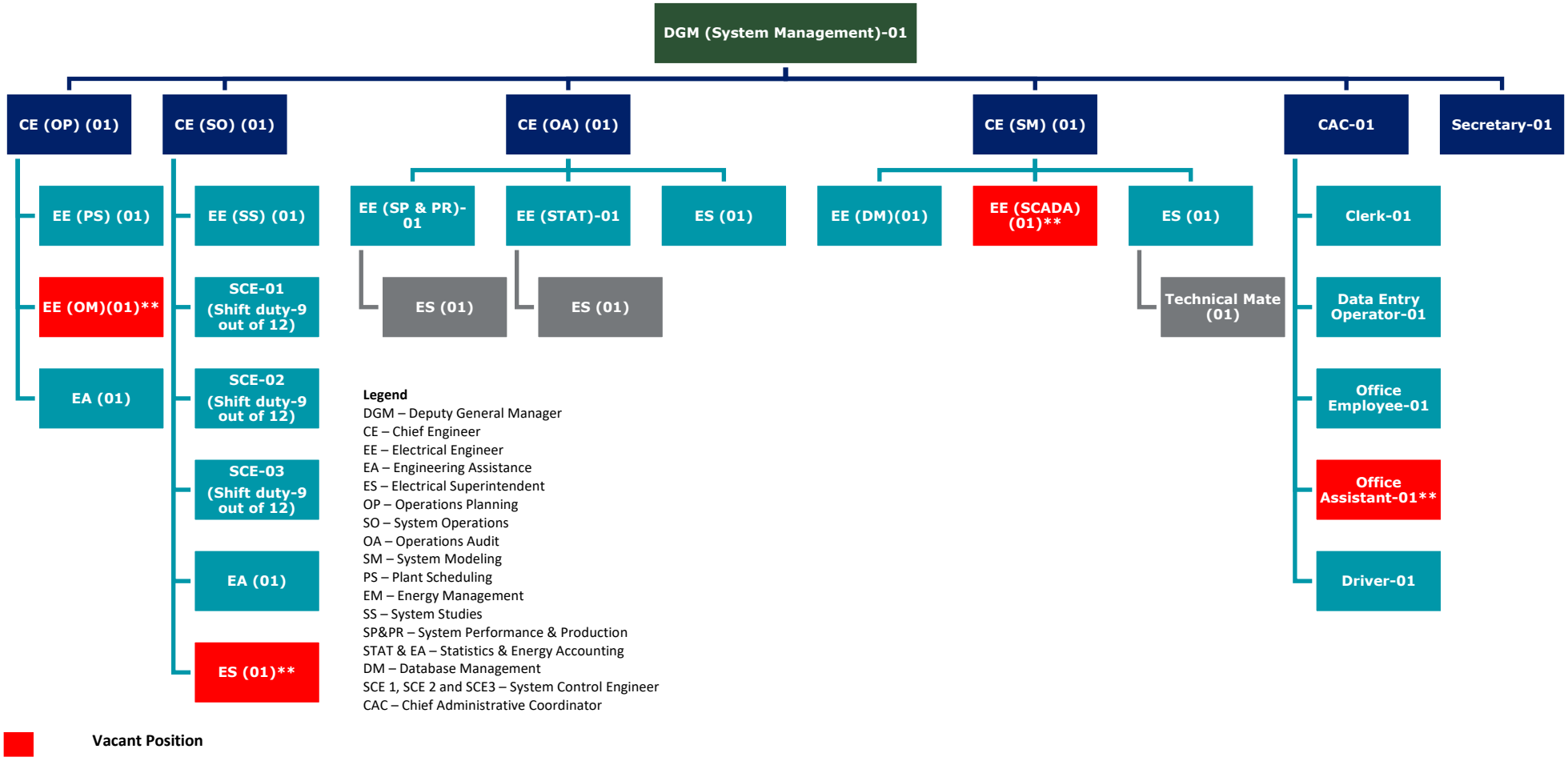


c) **No information on record of updation of the documented procedure** – The current documented procedure shared do not contain any historical record of updation(s) undertaken by the SCC for the procedures.

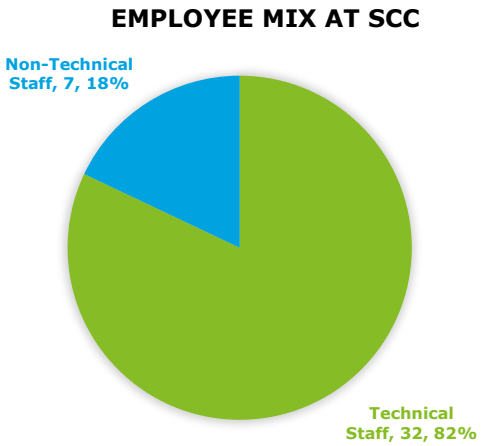
2.2 Review of the Documented Institutional Structure of SCC

The current Institutional Structure of SCC has been illustrated below:

Figure 7: Current Institutional Structure of System Control Center, Sri Lanka



There is a total of 32 positions for Technical Staff and 7 for Non-Technical Staff. For proper functioning of the SCC all the above positions need to be occupied at all times. Currently, as per the documented Organization Structure, there are 4 vacant positions with 1 being a Non-Technical position.



2.3 Review of the Disclosure Practice of SCC (based on documents and information received)

Table 2: Review of Disclosure Practices of SCC (based on documents & information received)

Grid Code reference	Description	Current Status [1]
Grid Code 4.17.7(a) – Daily Report	• Summary of system operations, incidents, events such as system loadings at night peak, day peak and off peak, generation by plant, system failures, customer complaints, demand control activities, planned outages, etc. for the preceding 24 hour period • To be made available by 09.00 hrs of the following day	• Daily Generation summary report "Gensum" is prepared and submitted on daily basis to the PUCSL and other relevant parties.
Grid Code 4.17.7(b) – Outage Report	• Detailed report whenever a total system outage or a partial outage occurs	• Failure reports are submitted to Cooperate Strategy branch to send to PUCSL
Grid Code 4.17.7(c) – Monthly Report	• Statistical analysis of the system performance, covering system outages, demand control measures, quality of supply indicators, etc.	• Submitted by CEB up to October 2020 – however, no details of the same is available [2]
Grid Code 4.5.4 – Year Ahead Plan	• CEB to prepare expected energy balance and plan for system operation for the next year • CEB to submit provisional Year Ahead Plan to PUCSL by 30 April and 31 October every year for approval • After PUCSL's approval, CEB to post the Plan on website for public access	• Year ahead energy forecast is submitted to the Finance Division for budget preparation. • Six month ahead energy forecast is submitted to energy marketing branch for bulk supply Tariff calculation. • Preparation of Energy Balance for SPPA Tariff in each year. • Website publication in not carried out by SCC.
Grid Code 4.5.5 – Monthly Updated Plan	• No later than 15 days before the end of the month, the System Operator shall submit to PUCSL, the updated Year Ahead Plan for the remaining months until the completion of the current year	• Monthly updated plan for next 12 months as rolling plan is submitted to Cooperate Strategy branch since 2013, on monthly basis before 10th of

[1] As per CEB Letter dated 1st January 2021 (Ref: PUC/AP19/CP/TEA/01My ref: AGM(CS)/DGM(CS&RA)/Tr. Li.)
[2] As per CEB letter to PUCSL no. DGM(CS&RA)/RA/Dispatch Procedure dt. Nov 4, 2020. Sample copy of the report is yet to be shared with us.

Grid Code reference	Description	Current Status [1]
	• By the same date, the System Operator shall post the updated Plan in its website for public access	the current month as per the *"Methodology of merit order dispatch".*
Grid Code 4.5.6 – Week Ahead Plan	• At 15 hrs. of the last working day of a week, the System Operator shall notify the Licensees the results of the Week Ahead Plan • By the same date, the System Operator shall post the updated Week Ahead Plan in its website for public access	• Data is currently not being submitted by Generation and Distribution Licensee for the preparation of Week Ahead Plan. *(Weekly machine availability shall be submitted by the generation licensee. Weekly demand forecast shall be furnished by the Distribution Licensee (Monthly and Yearly). Without these details SCC is not in a position to submit the Week ahead Plan. Distribution and Generation code indicated in those details have to be submitted)*

3. Study of Select System Operators

3.1 Sri Lanka's Plan for RE Capacity Addition

As per CEB's Long Term Generation Expansion Plan 2018-37[3], generation from Other Renewable Energy sources (except for Large Hydro) is expected to increase from present 10% to 20% by 2020. By 2037, RE penetration will have a significant impact on the national grid and optimum resource planning would be required to maintain system stability and grid integrity.

Figure 8: Sri Lanka Long Term Generation Plan - Installed Capacity & Fuel Mix

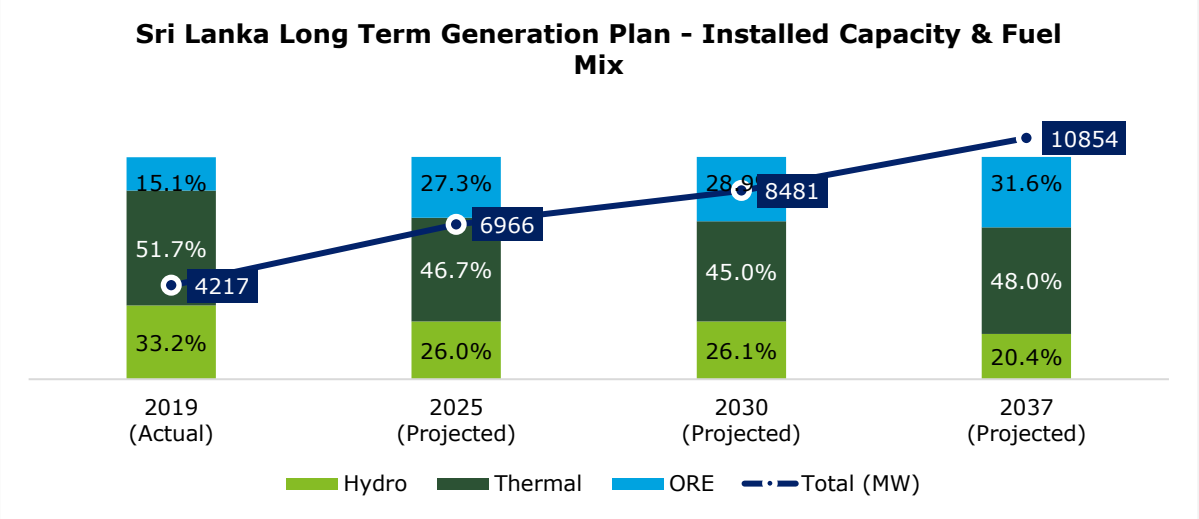
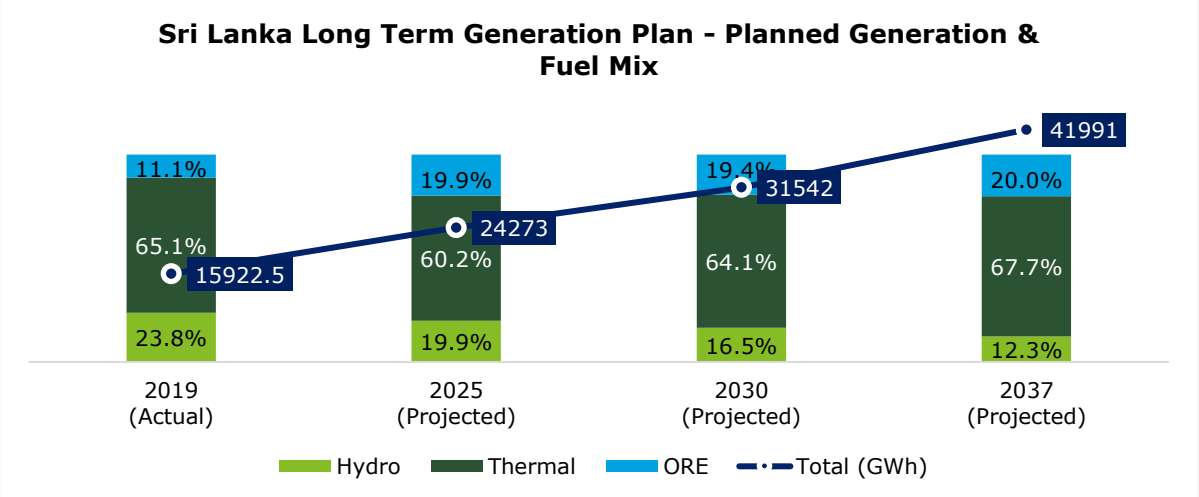


Figure 9: Sri Lanka Long Term Generation Plan – Planned Generation & Fuel Mix

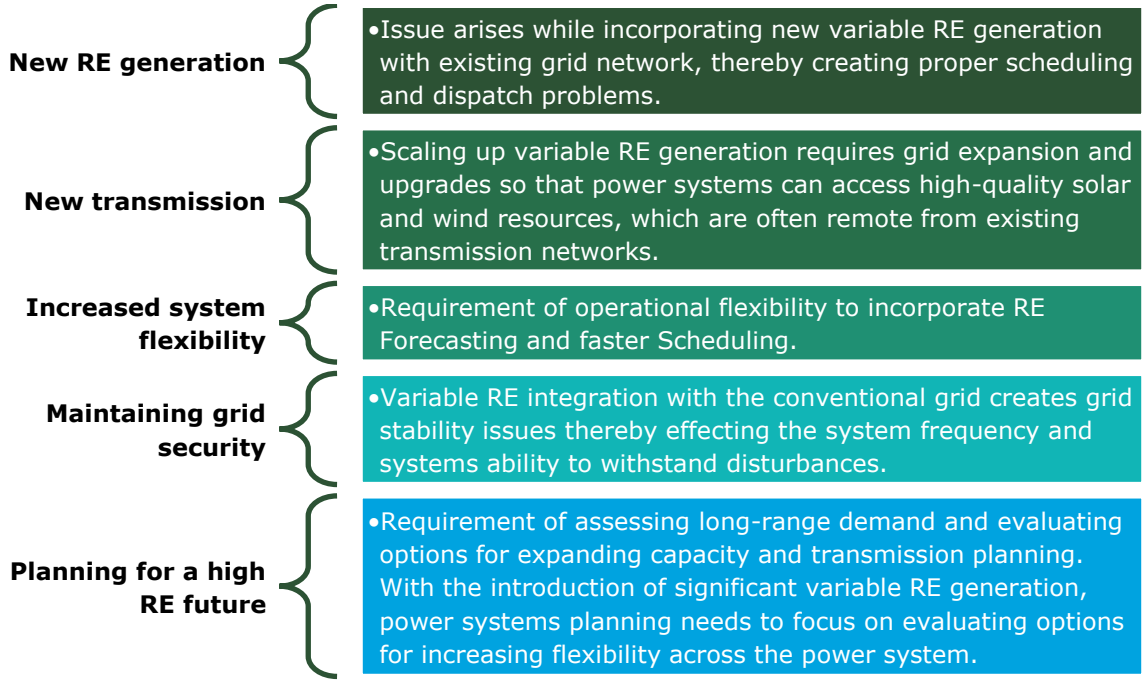


3.1.1 Potential Challenges with RE Integration

As more Renewable Energy will be added to the Sri Lankan grid, there will be a need to maintain a robust integration method to make RE integration cost effective while simultaneously maintaining or increasing grid stability and reliability. Grid integration spans a variety of issues. Some of the major areas for concern are highlighted below:

[3] For FY2019 the actual installed capacity, achieved generation and fuel mix has been considered

Figure 10: Key Challenges for Grid Management & System Operation due to increase in RE Share



The above highlighted challenges need to be addressed with prudent practices for ensuring smooth grid and system operations in Sri Lanka in the coming decade.

3.2 Study of Practices of Other Select System Operators

As part of our approach, we have assessed the Institutional Structure, Capacity Building Activities as well as public disclosure practices of Select System Operators globally to identify key areas which may be introduced / strengthened for the SCC. The below section enumerates our study of some of the global peers of the SCC.

3.2.1 Eastern Region Load Despatch Center (India)

3.2.1.1 Key Role and Functions Performed

The Eastern Region Load Despatch Center, India (ERLDC) is the nodal System Operator working under the National Load Despatch Center, India. It covers the operations of 5 States and Bhutan (with 49,193 Transmission Network in C-Kms and Effective Generating Capacity of utilities as on 31.03.20). The major functions of the ERLDC are:

- **Facilitates Integrated operation** for improved quality, Security and Reliability of Power Supply on Regional Basis
- Provides Avenues for **Intra-Regional and Inter Regional Exchanges**
- **Telemetry** - Live Data from Major Generating Plants and Sub-stations
- **Co-ordinates Drawal Schedule** from for all ISGS constituents
- **Issues** clearances for outage of elements for maintenance work
- **Supplies information** about grid performance to higher management

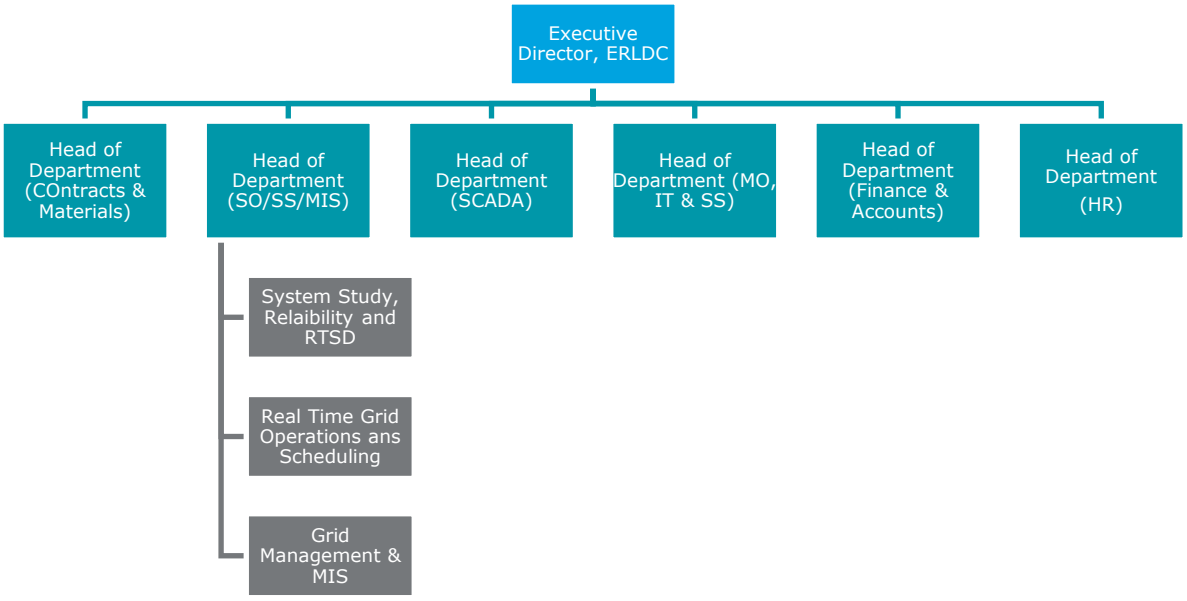
- **Monitors** generation of Central Power Stations and Power Flow in major lines and Tie Lines
- Processes Special Energy Meter readings for **Bulk Power Energy Settlement**
- **Responsible for implementation of IEGC and Regulatory Directives**
- Strives to be a global institution of excellence for reliable & resilient power systems, fostering efficient electricity markets, promoting economy and sustainability.

3.2.1.2 Institutional Placement

ERLDC is a sub body under National Load Despatch Center in India. The overarching institution for National Load Despatch Center is Power System Operation Corporation Limited (POSOCO)

3.2.1.3 Organisation Structure

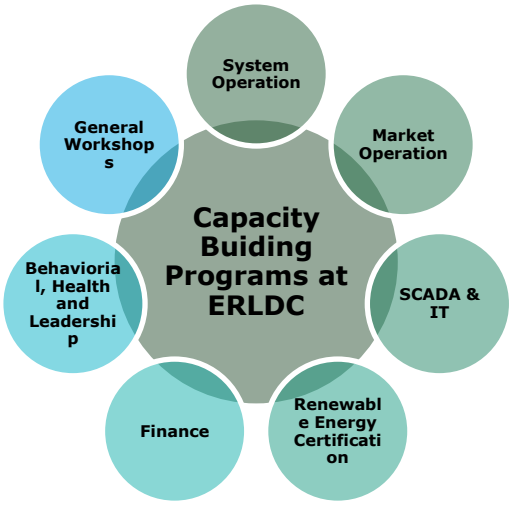
Figure 11: Organization Structure of Eastern Region Load Despatch Center (India)



3.2.1.4 Training & Development Practice

In order to promote competency and commitment among employees, POSOCO (the overarching body for Load Despatch Centres in India) has inculcated innovation and excellence through capacity building programs. POSOCO has been regularly organising learning and development programs for capability enhancement. These include regular visit to generation, transmission sites and promoting interactions with field engineers for mutual appreciation and underrating each other's' concerns.

Figure 12: Key Areas of Training & Development for ERLDC, India



The **detailed Capacity Building Activities for ERLDC has been illustrated Annexure 16.1**

3.2.1.5 Public Disclosure Practice

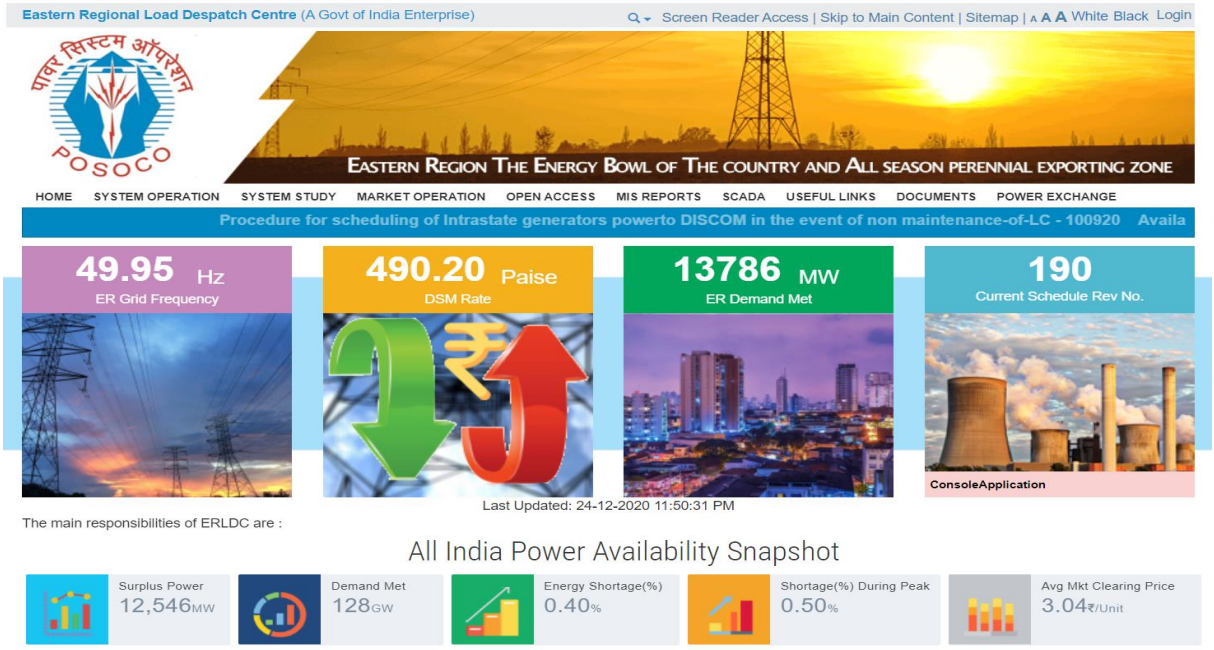
The major public disclosures by ERLDC have been enumerated below which are available on its website:

Table 3: Public Disclosure Practice of ERLDC, India

Sl. No.	Information available in Public Domain
1	**Particulars of its Organization, functions, and duties**
2	**Power and duties of its Officers and employees**
3	**Directory of its Officers and Employees**
4	**Annual Reports**
5	**Functions of POSOCO & Full Origin available for POSOCO and RLDCs**
6	**Technical Reports related to Frequency Reserve Ancillary Services (FRAS), Frequency profile, Renewable Energy Certificate, payment mechanism, Grid disturbances and other publications**
7	**Data related to Demand Side Management (DSM), Aggregate Technical & Commercial Losses (ATC), Open Access, Congestion Point Of Connection data and transmission losses**
8	**Links to other Government portals like RLDC, FOLD, MoP, MNRE, CERC**

A **snapshot** from the ERLDC website is shown below:

Figure 13: Snapshot of Disclosure Practice of ERLDC, India



3.2.2 Gujarat State Load Despatch Centre (India)

3.2.2.1 Key Role and Functions Performed

The Gujarat State Load Despatch Centre is one of the many SLDCs operating alongside the National Load Despatch Centre and other Regional LDCs.

The principal activities are highlighted below:

- **Operating the Gujarat electrical system** in most economical through economic load despatching, merit order operation.
- Maintains **continuous contact** with other utilities like GUVNL (Trading Co.), GSECL (Generating Co.), DISCOMs (DGVCL, MGVCL, UGVCL, PGVCL), other IPPs, CPPs and Non-Conventional Generating Units
- **System operation and control covering contingency analysis and operational planning on real time basis**.
- **Scheduling / re-scheduling of generation**.
- **System restoration following grid disturbances.**
- **Metering and data collection.**
- **Compiling and furnishing data pertaining to system operation.**
- **Operation of state UI pool account, state reactive energy account.**

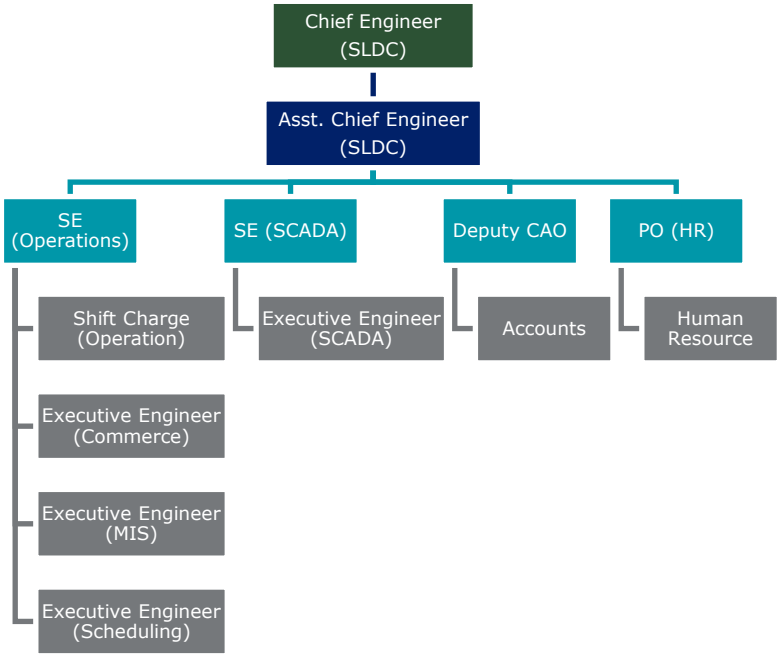
The Gujarat SLDC operates with three Area Load Despatch Centre (ALDC) set up at Gandhinagar, Jambuva and Jetpur under Unified Load Despatch Centre scheme of Western Region and handles 65,608 C-km of Transmission Lines and 28,227 MW of installed capacity.

3.2.2.2 Institutional Placement

State Load Despatch Centre, Gujarat is a wholly owned subsidiary of Gujarat Energy Transmission Corporation Limited, the electrical power transmission company in the state of Gujarat.

3.2.2.3 Organisation Structure

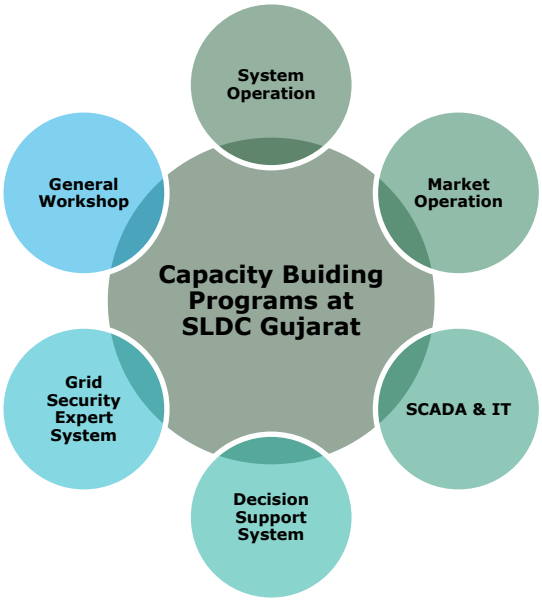
Figure 14: Organization Structure of Gujarat State Load Despatch Center, India



3.2.2.4 Training & Development Practice

At SLDC Gujarat, all Engineers are imparted training relevant to their role in the organization. Briefing and workshops are regularly held as part of capacity building imitative of SLDC workforce. Several initiatives have been taken up by **Forum of Load Despatchers (FOLD), India** for institutional capacity building of the Load Despatch Centres. Benchmarking of infrastructure and human resources at various LDCs in India through surveys conducted by FOLD have been extremely useful for identifying best practices and gaps.

Figure 15: Key Areas of Training & Development for Gujarat Load Despatch Center, India



3.2.2.5 Public Disclosure Practice

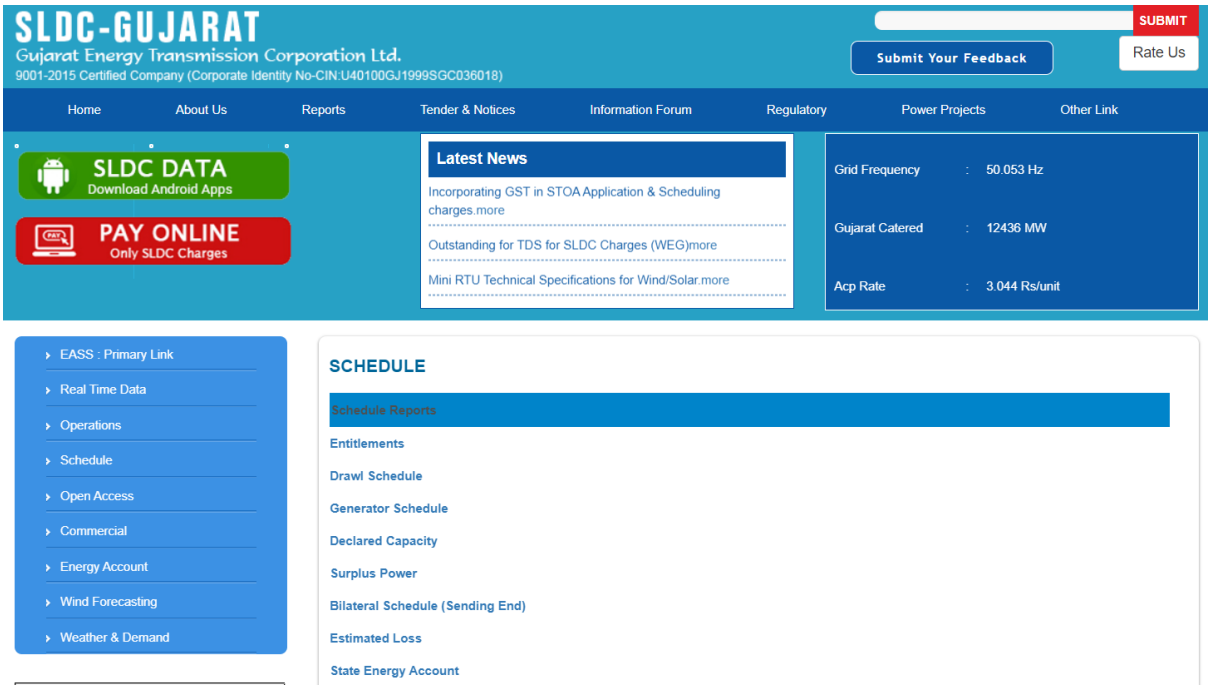
The major public disclosures by SLDC Gujarat have been enumerated below which are available on its website

Table 4: Public Disclosure Practice of Gujarat SLDC, India

Sl. No.	Information available in Public Domain
1	**Particulars of its Organization, functions, and duties**
2	**Power and duties of its Officers and employees**
4	**Links for Annual Reports, Installed Capacity, Merit order details**
6	**Technical Reports related to Market Operation, System Study**
7	**Links for digital services like e-tendering, applications, complaints**
8	**Links to other State Government portals**

A **snapshot** from the Gujarat SLDC website is shown below:

Figure 16: Snapshot of Disclosure Practice of Gujarat State Load Despatch Center, India



3.2.3 Grid System Operator (Malaysia)

3.2.3.1 Key Role and Functions Performed

Grid System Operator (GSO) Malaysia looks after the day-to-day real-time operations and management of the Peninsular grid system. GSO is also responsible for short- and medium-term planning of the transmission network and generation facilities. Including interconnections with Thailand and Singapore.

The principal activities are highlighted below:

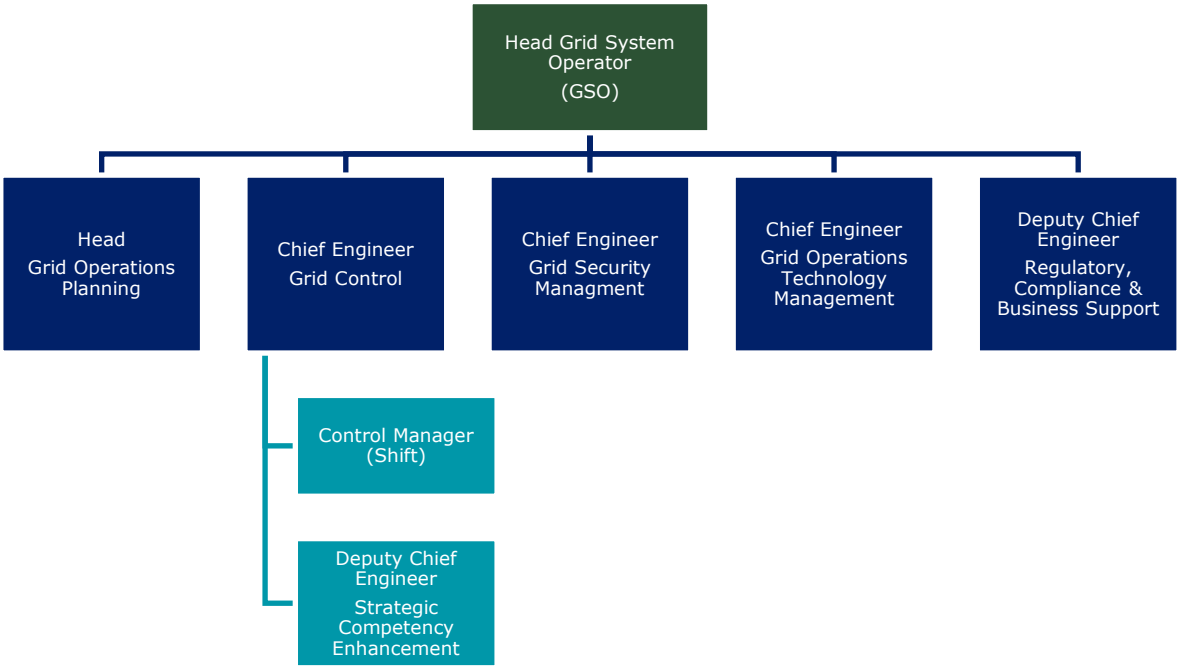
- **Grid Generation Control-** Real time optimization for generators with accurate and efficient security constrained dispatch
- **Grid Network Control-** Plan for Contingencies, formulate the short and medium term operational strategic plan, manage, and formulate an effective transmission network maintenance
- **Grid Security Management**- Enhancement of grid security by deploying advanced mitigation measures and the utilization of advanced analytics tools and technologies.
- **Grid Technology Management-** Operating and Managing State of the Art Control Centre Facilities for GSO.
- **Regulatory, Compliance & Business Support**- Conduct and manage all technical, compliance and quality audits efficiently and ensures that all corrective action plans are implemented and closed out effectively and in a timely manner.

3.2.3.2 Institutional Placement

Grid System Operator (GSO) is a ring-fenced entity within TNB which is responsible for operational planning, real-time re-scheduling, dispatch, and control of the grid system in compliance with the provisions of the Grid Code and coordinates all parties connected to the Grid System.

3.2.3.3 Organisation Structure

Figure 17: Organization Structure of Grid System Operator (GSO) Malaysia



3.2.3.4 Public Disclosure Practice

The major public disclosures by GSO have been enumerated below which are available on its website:

Table 5: Public Disclosure Practice of Grid System Operator (GSO) Malaysia

Sl. No.	Information available in Public Domain
1	**Particulars of its Organization, functions, and duties**
2	**Information on Business areas and Quality initiatives by GSO**
3	**Power and duties of its Officers and employees**
4	**Information on Grid Code Terms of Reference**
5	**List of Operational Thermal and Hydroelectric Power Plants**
6	**System Data related to Power station info, Generation, Demand, Fuel Mix, System Constraints**

3.2.4 California ISO (CAISO)

3.2.4.1 Key Role and Functions Performed

California ISO ensures the safe and reliable transportation of electricity on the power grid. It provides open and non-discriminatory access to the bulk of the state's wholesale transmission grid, supported by a competitive energy market and comprehensive infrastructure planning efforts.

The principal activities are highlighted below:

- **Tracks** generation and transmission schedules submitted a day in advance to better manage or avoid real-time bottlenecks

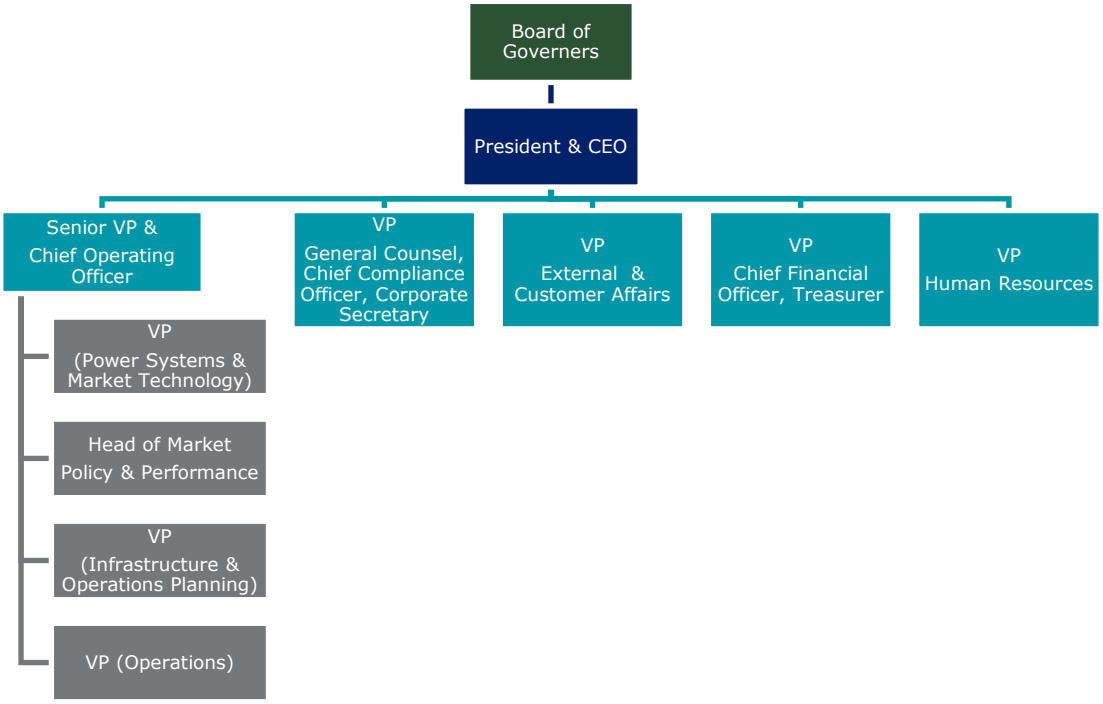
- **Provides** a one-stop shop for trading and evaluating the electricity bids, transmission capacity and reserves needed to keep the grid in balance
- **Creates** a transparent system of electric prices based on the cost of generating and delivering it

3.2.4.2 Institutional Placement

Regulated by Federal Electricity Regulatory Commission (FERC) it is one of the largest ISOs in the world and oversees the operations of California's bulk power system, transmission lines, and electricity market generated and transmitted by its member utilities.

3.2.4.3 Organisation Structure

Figure 18: Organization Structure of California ISO (CAISO)



3.2.4.4 Training & Development Practice

The ISO works continuously towards the development of its employees, so they are on the leading edge of the latest technology and innovation available. ISO's integrated approach enhances the knowledge and skills of its employees, developing technical experts as well as strengthening leadership and managerial capabilities.

- **Tuition Reimbursement** - for career-related courses in pursuit of a degree or certificate program
- **Performance Planning Program** - Quarterly review sessions provide for different opportunities for career planning discussions with your manager
- **Corporate rotation programs, leadership development plans and the dual technical and management career paths**
- **Opportunities to expand** the breadth of skills and knowledge through exploring internal postings and interim assignments

- **Operations Simulator** -Engineers and operators participate in on-going simulations where they learn to master new tools and analyze in real time, scenarios on the intricacies of an advanced grid with renewable resources and complex markets.

3.2.4.5 Public Disclosure Practice

The major public disclosures by CAISO have been enumerated below which are available on its website

Table 6: Public Disclosure Practice of California ISO (CAISO)

Sl. No.	Information available in Public Domain
1	**Particulars of its Organization, functions, and duties**
2	**Information on Business areas, Industry insights**
3	**Reports on Strategic plans, Corporate brochures**
4	**Grid information details related to Generator interconnection, Transmission planning**
5	**Market Operations reports and bulletins**
6	**Financial reports in the form of Budget, Financial reports, Audit reports, Debt financing**
7	**ISO publishes regular reports and other documents that are important to understanding generation interconnection, reliability, and transmission planning- Technical Bulletin**
8	**Renewables integration reports and studies & other RE related information like Using renewables to operate a low-carbon grid**
9	**System Data related to Power station info, Generation, Demand, Fuel Mix, System Constraints**

3.2.5 Power Grid Company of Bangladesh

3.2.5.1 Key Role and Functions Performed

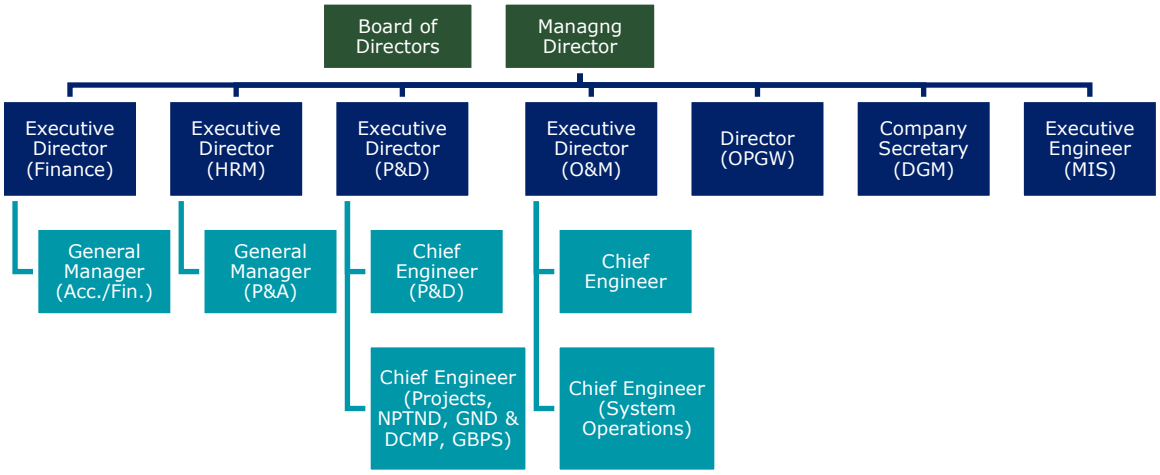
Power Grid Company of Bangladesh owns and operates the power grid in Bangladesh. The main role of PGCB is to maintain a continuous balance between electricity supply from power stations and demand from consumers, and also ensure strategic measures for contingencies. Other key areas of operation include real-time dispatch of generation and managing grid security. PGCB currently operates with 12,285 C-km of Transmission Lines and has a dispatch capacity of 24,418.35 MW at 33kV level.

3.2.5.2 Institutional Placement

PGCB is a subsidiary of Bangladesh Power Development Board (BPDB) which is responsible for planning and developing the nation's power infrastructure and for operating much of its power generation facilities. The National Load Dispatch Centre (NLDC), which is the System Operator of Bangladesh, is a division within the PGCB.

3.2.5.3 Organisation Structure

Figure 19: Organization Structure of Power Grid Company of Bangladesh



3.2.5.4 Training & Development Practice

PGCB Bangladesh conducts very specific targeted training of their workforce to keep them updated about advancements in the power industry at the same address the needs of HRD through hard and soft skill development training programs.

Figure 20: Key Areas of Training & Development for Power Grid Company of Bangladesh

The **detailed Capacity Building Activities for PGCB has been illustrated Annexure 16.2**

3.2.5.5 Public Disclosure Practice

The major public disclosures by PGCB have been enumerated below which are available on its website:

Table 7: Public Disclosure Practice of Power Grid Company of Bangladesh

Sl. No.	Information available in Public Domain
1	Particulars of its Organization, functions, and duties
2	Organization Structure
3	Details of New/Upcoming and completed project info available
4	Annual Reports, Daily and Monthly Operational Reports
5	MIS and ESIA Reports
6	Information and Documents related to Transmission Lines, Sub-stations, National Grid network, Grid map
7	Other compliance documents like OHSAS Documents, OMS, Annual Training Plan, Annual Procurement Plan, Budget, Grid Code
8	Links to digital services like e-auction, e-filing, Grievance Redress system
9	Links to other Government portals

3.2.6 Key Takeaways for SCC

3.2.6.1 Institutional Strengthening

We have assessed the organization structure of some major System Operators viz. ERLDC and SLDC in India, GSO Malaysia, California ISO. In most cases, there is a separate department to tackle the different operations associated with Load Despatch Centre. These departments are in constant communication with each other through internal reporting and daily/weekly technical reporting of LDCs performance. We have compared the organization structure for identifying the major functions of these system operators and presented below:

Table 8: Comparison of Major Functional Setup of International System Operators and SCC, Sri Lanka

ERLDC, India	Gujarat SLDC, India	Malaysia GSO	California ISO	SCC, Sri Lanka
Major Functions				
System Operation / Scheduling – Despatch	**System Operation / Scheduling – Despatch**	**Grid Operations and Planning / Scheduling – Despatch**	**System Operations**	**System Operations**
System / Technical Study	**-**	**Grid Security Solutions & Analytics**	**Market & Infrastructure Development, Quality & Renewable Integration**	**System Study, System Modelling, Operations Audit**
MIS	**MIS**	**Regulatory Compliance & Business Support**	**-**	**Database Management**
SCADA & IT	**SCADA**	**SCADA and EMS, Grid System Technologies, Protection and Architecture**	**Technology**	**SCADA**
Market Operation	**Commercial**	**Commercial**	**Market Monitoring**	

ERLDC, India	Gujarat SLDC, India	Malaysia GSO	California ISO	SCC, Sri Lanka
		Transaction Mgmt		
Non Technical (F&A, HR)	**Non Technical (Accounts, HR)**	**-**	**-**	**Non Technical (Admin)**
Miscellaneous (Contracts & Material)			**Miscellaneous (General Counsel, Policy & Client Service)**	

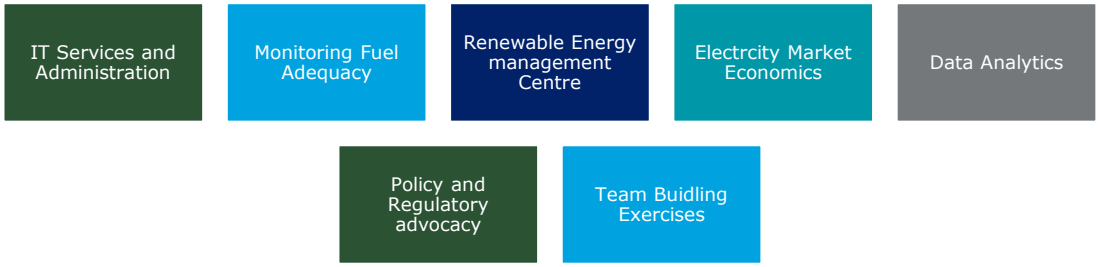
General Insights from the above comparison:

- **Presence of Dedicated MIS** – Most of the System Operators are seen to have a separate / distinct department for performing the MIS function. Considering that the current SCC functional setup required individual departments to prepare reports for management, a separate MIS function may be envisaged to ensure coordinated MIS reporting.
- **Dedicated Team for Regulatory Compliance** – Regulatory Compliance is seen to be part of the MIS functional setup for most global system operators. Considering the compliance assessment of the SCC's documented procedure, a separate function for Regulatory Compliance may be introduced in the SCC or integrated within the proposed MIS function above to take care of matters related to public disclosure and compliance with grid code.

3.2.6.2 Training & Development Practice

Every major system operator acknowledges the fact that capacity building of workforce through in-house training programs is essential to keep up with changing scenario of the power sector due to RE Integration. From our assessment of different ISOs/TSOs, some major areas have been identified for capacity building that are currently being carried. These areas are specific to Grid Operators and are highlighted below:

Figure 21: Key Training & Development topics undertaken by System Operators due to changing power sector scenario



3.2.6.3 Public Disclosure Practice

Most of the system operators globally ensure public reporting of their activities and data pertaining to system operation in line with their Grid Code and other regulatory requirements. Considering our Review of the Disclosure Practice of SCC (based on documents and information received), the SCC can strengthen their disclosure functions to ensure compliance to the Grid Code.

4. Evaluation of Self Assessment Report

The SCC provides PUCSL with a self-assessment report of its performance for the preceding year. The self-assessment report is a comparison of actual performance and targeted performance along with variance analysis based on performance metrics.

The self-assessment report is prepared considering the follwojng performace metrices:

- System Availability (Yearly/Monthly)
- Optimal Schedule Generation Cost vs Actual (Yearly/Monthly)
- Energy Supply Forecast vs Actual (Yearly/Monthly)
- Hydro Generation Forecast vs Actual (Yearly/Monthly)
- Thermal Generation Cost vs Actual (Yearly/Monthly)
- Demand Forecast vs Actual (Yearly/Monthly)
- Inflow Forecast vs Actual (Yearly/Monthly)

4.1 Analysis of Self Assessment Report

Based on the discussion with PUCSL and CEB officials, we have analysed the self assessment report for 2019 provided by SCC and the findings are provided below considering '**DRY SEASON'** to be 4 months.

The Self-Assessment report is categorised into: (a) Year Ahead Operational Plans and (b) Month Ahead Operational Plans. The major operational metrics have been analysed and presented here.

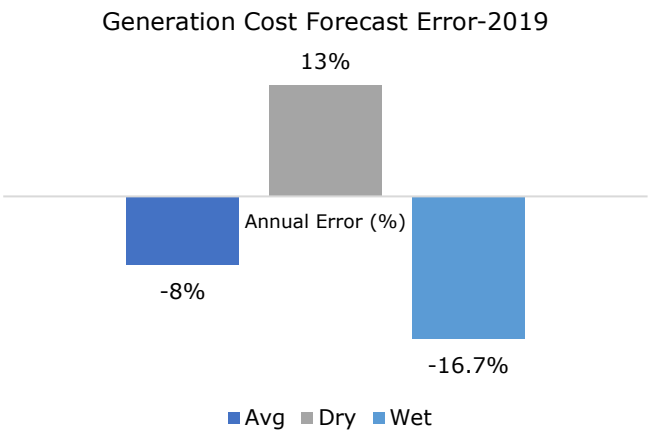
4.1.1 Year Ahead Operational Plans

4.1.1.1 Forecast Optimal Schedule Generation Cost vs Actual

Generation Cost Forecast Error	2019		Wet (%) considering Dry is 4 months
	Avg	Dry	
Annual Error (%)	**-8%**	**13%**	**-16.7%**

Figure 22: Generation Cost Forecast Error -Year 2019

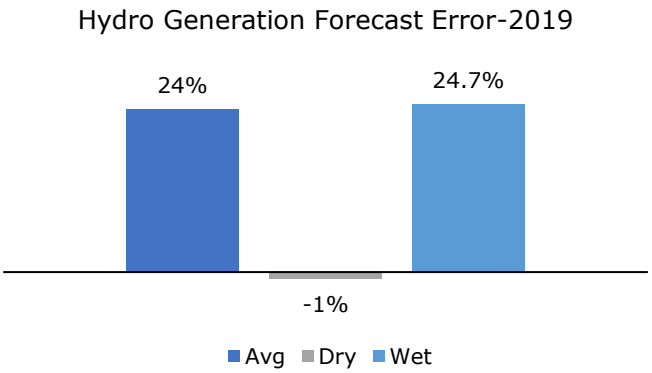
The Generation Cost forecast variance is in the range of 13% during the Dry Period and -16% during the Wet Period. This indicates a wide variance between projected cost and actuals for the year 2019. In order to benchmark SDDP procedures that is adopted globally this cost-wise variance needs to be taken into account. As an institutional practice it is critical that ex-post variance analysis and periodic back testing needs to be considered to optimize the forecasting procedures.



4.1.1.2 Hydro Generation Forecast vs Actual

Hydro Generation Forecast Error	2019		Wet (%) considering Dry is 4 months
	Avg	Dry	
Annual Error (%)	**24%**	**-1%**	**24.7%**

Figure 23: Hydro Generation Forecast Error -Year 2019

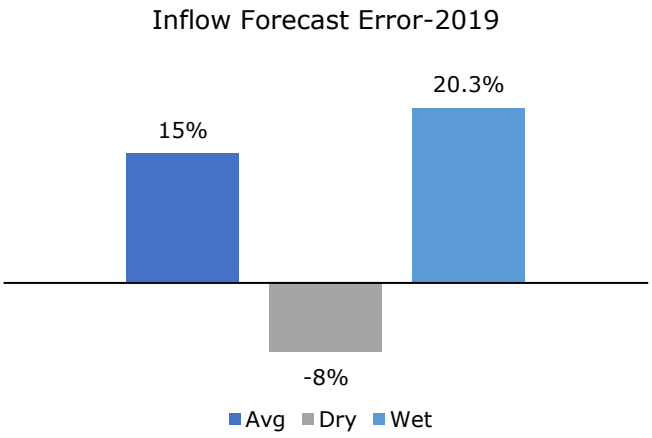


The Hydro Generation forecast variance is in the range of -1% during the Dry Period and -25% during the Wet Period. It is evident that the Hydro Generation forecast error is around +/-25% for the year 2019. While it is understood that wet season hydro forecasting will be subject to weather, topology variances, it is important considering future addition of renewables in the grid that the level of unpredictability for hydro generation needs to be minimized. Periodic back testing and actual / scheduled variance analysis is expected to identify the key plants with forecasting constraints. Additionally, models / tools for inflow forecasting should also be considered.

4.1.1.3 Inflow Forecast vs Actual

Inflow Forecast Error	2019		Wet (%) considering Dry is 4 months
	Avg	Dry	
Annual Error (%)	**15%**	**-8%**	**20.3%**

Figure 24: Inflow Forecast Error -Year 2019



The Inflow forecast variance also has a high variance of around 20% considering the Dry and Wet seasons. The dispatched energy of hydro power plants into the electrical system of Sri Lanka is as high as 30%. As per CEB's Long Term Generation Forecast, Sri Lanka is expected to increase their share of thermal as well as Renewable Energy in the power supply mix to supplement their rapidly growing energy demand. Renewable energy (excluding Hydro) is expected to increase to ~20% in the future. To apply effective inflow forecasting for the Sri Lankan Electricity Market using stochastic optimisation, the simulation needs to be adjusted with input parametric adjustments in order to get optimal inflow forecasting in near future.

In similar process, the Month Ahead Operations plans has been assessed and is represented below:

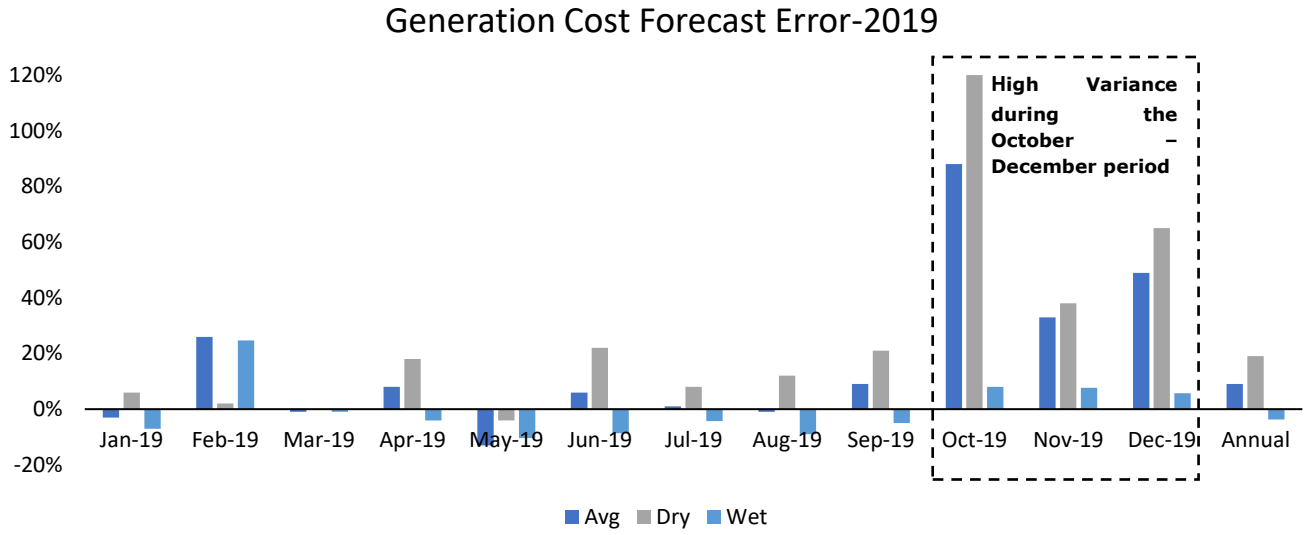
4.1.2 Month Ahead Operational Plans

4.1.2.1 Forecast Optimal Schedule Generation Cost vs Actual

Generation Cost Forecast Error	Year		Wet (%) considering Dry is 4 months
	Avg	Dry	
January	-3%	6%	-7.0%
February	26%	2%	24.7%
March	-1%	0%	-1.0%
April	8%	18%	-4.0%
May	-13%	-4%	-10.3%
June	6%	22%	-8.7%
July	1%	8%	-4.3%
August	-1%	12%	-9.0%
September	9%	21%	-5.0%
October	88%	120%	8.0%
November	33%	38%	7.7%
December	49%	65%	5.7%
Annual Error	**9%**	**19%**	**-3.7%**

The Monthly Generation Cost forecast variance is in the range of 19% during the Dry Period and around 4% during the Wet Period with as high as 120% variance during the months of October, November, and December.

Figure 25: Generation Cost Forecast Error -Year 2019

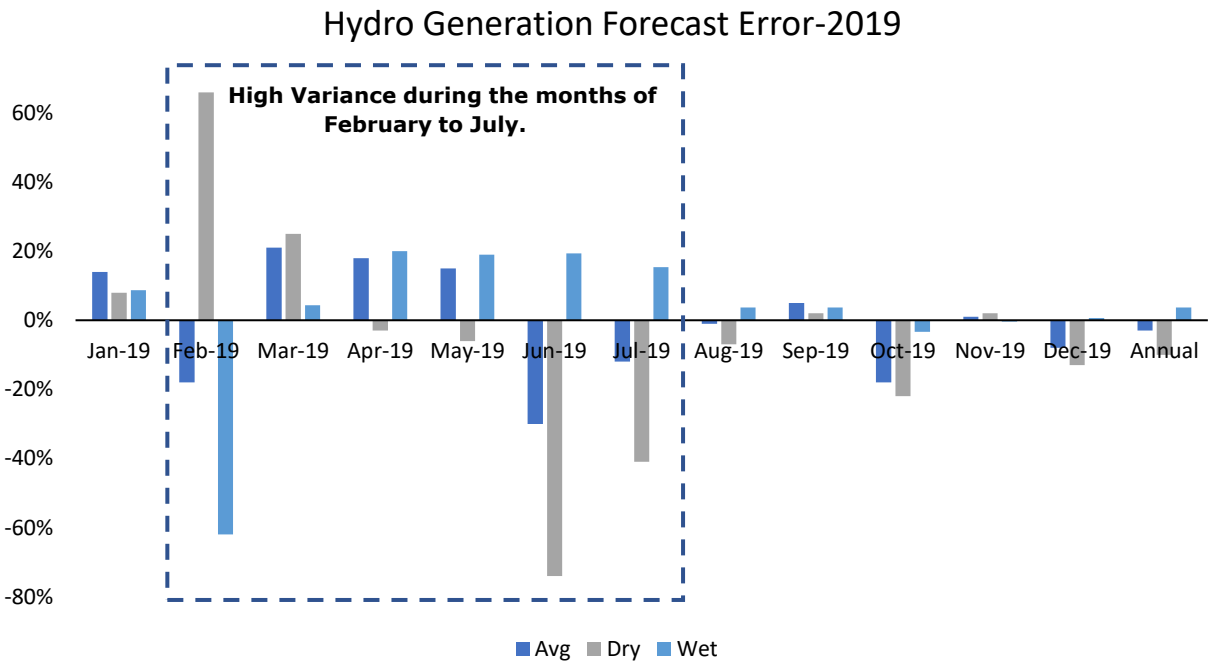


4.1.2.2 Hydro Generation Forecast vs Actual

Hydro Generation Forecast Error	2019		Wet (%) considering Dry is 4 months
	Avg	Dry	
January	14%	8%	8.7%
February	-18%	66%	-62.0%
March	21%	25%	4.3%
April	18%	-3%	20.0%
May	15%	-6%	19.0%
June	-30%	-74%	19.3%
July	-12%	-41%	15.3%
August	-1%	-7%	3.7%
September	5%	2%	3.7%
October	-18%	-22%	-3.3%
November	1%	2%	-0.3%
December	-8%	-13%	0.7%
Annual Error	**-3%**	**-10%**	**3.7%**

The Monthly Hydro Generation forecast variance is in the range of -75%-66% during the Dry Period and in the range of -62%- 20% during the Wet Period, with abnormally high variance during February to July.

Figure 26: Hydro Generation Forecast Error -Year 2019

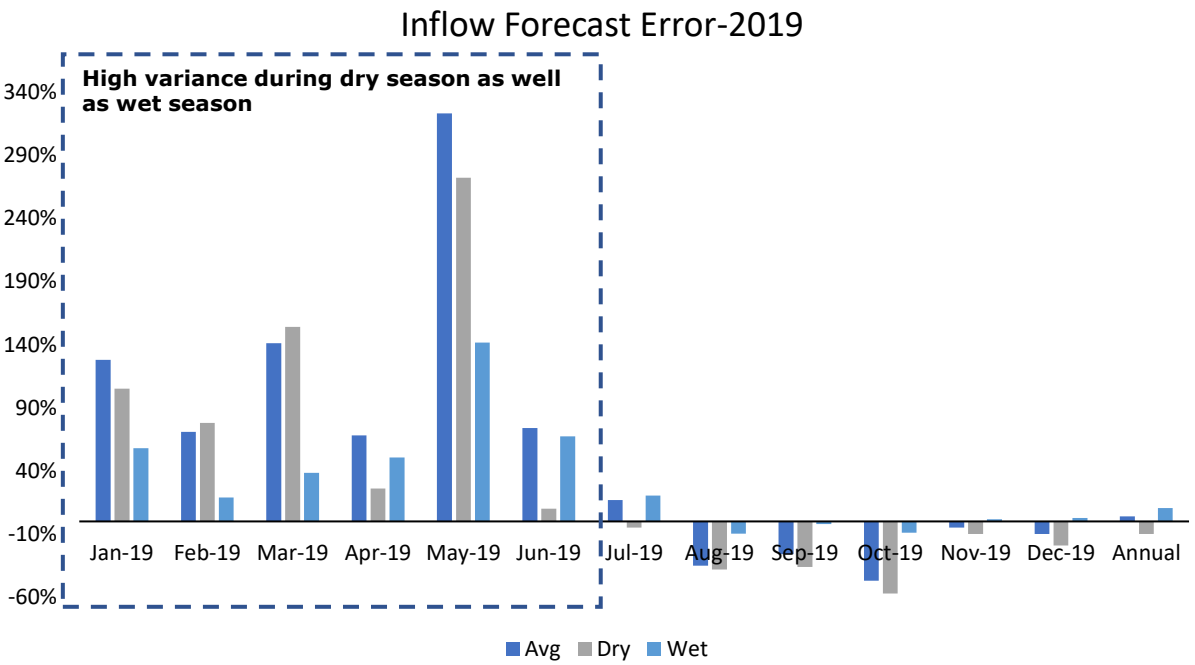


4.1.2.3 Inflow Forecast vs Actual

Inflow Forecast Error	2019		Wet (%) considering Dry is 4 months
	Avg	Dry	
January	**128%**	**105%**	**58.0%**
February	**71%**	**78%**	**19.0%**
March	**141%**	**154%**	**38.3%**
April	**68%**	**26%**	**50.7%**
May	**323%**	**272%**	**141.7%**
June	**74%**	**10%**	**67.3%**
July	**17%**	**-5%**	**20.3%**
August	**-35%**	**-38%**	**-9.7%**
September	**-26%**	**-36%**	**-2.0%**
October	**-47%**	**-57%**	**-9.0%**
November	**-5%**	**-10%**	**1.7%**
December	**-10%**	**-19%**	**2.7%**
Annual Error	**4%**	**-10%**	**10.7%**

As detailed in Section 13.1.1.3, the inflow forecasting for Hydro Power Plants has a high variance. This is evident from below that during the months of January to July the variance is abnormally high between projected values and actual inflow during dry periods as well as wet periods.

Figure 27: Inflow Forecast Error -Year 2019



5. Identification of operational procedures for revision

Over our engagement life cycle, we have studied the Grid Code, Dispatch Audit Guidelines and Self-Assessment Report. We also had conducted the gap analysis of SCC Documented Operational Procedures, comparison with Grid Code, Institutional Structure and Disclosure Practices of other select system operators. We also carried out a detailed quantitative analysis of the Self Assessment Report.

Based on our study and analysis we have identified the operational procedures that needs to be revised and adopted by SCC for improving the scheduling and dispatch process for the Sri Lankan Energy Market. The operational procedures identified are as follows:

Table 9: Operational Procedures identified for revision

Operational Procedures identified for revision and recommendation on global best practices adopted for use of SDDP
○ **Procedure for Availability Declaration by Generators and Drawal Schedule for Distribution Licensees** ➢ *Documented procedure with information related to Contact Persons, Mode of Communication, Day and Time Blocks for Availability Declaration, Availability declaration & Licensee drawal scheduling, Procedure for Availability Declaration & Licensee drawal scheduling with Formats for data submission.*
○ **Procedure for Day Ahead Hydrothermal Generation Scheduling and Dispatch & Publication** ➢ *Documented procedure for Preparation of Day-ahead 15 minutes Generation & Drawls Schedule, Revision of Schedule, Implemented Schedule with Formats for data submission.*
○ **Procedure for Non-declaration of Availability** ➢ *Monitoring of Non-compliance of terms/conditions/rules outlines under Grid Code with detailed procedure for Non-declaration of Availability*
○ **Procedure for Non-compliance to Scheduled Availability** ➢ *Monitoring of Non-compliance of terms/conditions/rules outlines under Grid Code with detailed procedure for Non-compliance to Scheduled Availability*
○ **Procedure for Demand Forecasting** ➢ *Monthly Energy and Maximum & Minimum demand forecast with detailed procedure for demand forecasting*
○ **Operational Procedure: Water Management Directives** ➢ *Detailed guidelines for dispatch of Water and procedure recommended for maintaining records related to Water Management*
○ **Ex-Post Analysis to be conducted by SCC** ➢ *Monitoring the compliance of operational procedures* ➢ *Monitoring the number of revisions in Schedule* ➢ *Real Time Injections vs Projections Shared and Variance Analysis* ➢ *Real Time Drawal vs Projections and Variance Analysis* ➢ *Preparation of Monthly Summary report* ➢ *Formats for data submission.*
○ **Global best practices for SDDP** ➢ *Basic Functions carried out using SDDP, Best practice adopted globally for forecasting, Stochastic Optimization, inflow forecasting and process improvements, personnel training, recommendations*

The above procedures have been discussed in detail in subsequent sections.

6. Procedure for Availability Declaration by Generators and Drawal Schedule for Distribution Licensees

This section sets out the context and background of the assignment.

6.1 Purpose

Declare day ahead peak and off peak availability by Generators

6.2 Scope

Detailed procedure for Availability & Entitlement Declaration

6.3 Procedure

a. Contact Persons

- The **System Control Centre Manager** shall be responsible for coordinating Availability Declaration on behalf of the System Control Centre (SCC).
- **For CEB Owned Generating Stations**: The In-charge of Generating Stations shall be responsible for sending availability schedule for each individual generating station and shallintimate the name, designation, and contact details (phone, fax, mobile and e-mail) of Officerfor his Plant to the System Control Manager.
- **For Licensee**: Concerned SE/Nodal officer of Licensee shall be responsible for furnishing drawl schedule and shall intimate the name, designation, and contact details (phone, fax, mobile and e-mail) of authorized Scheduling Officer to the System Control Manager.
- **For IPPs**: The In-charge of each IPP shall be responsible for declaring availability of their respective entity and shall intimate contact details (phone, fax, mobile and e-mail) of such authorized person to System Control Manager.
- Alternately, details of contact persons can be put up on the web-portal of each users/beneficiaries/generators for ease of reference.

b. Mode of communication

- For sharing of large volume of information in real time, the transfer of information betweenSystem Control Centre (SCC) and Users of power transmission system shall be through internet only.
- The System Control Centre (SCC) shall have facilities of voice communication with Control Centre with voice recording facilities, Fax machine and internet connection available 24x7 hours.
- However, during contingencies like internet failure/server issues, transfer of information may be communicated through alternate mode i.e., fax/telephone on request of SCC/Users.

c. Day and Time Blocks for Availability Declaration

- For the purpose of scheduling, each day would be divided into 96 blocks each of 15 minute duration starting from 0000 hrs. and ending with 2400 hrs.
- The availability would be declared on day-ahead basis and scheduling procedure willcommence at 09.00 hrs., on each day for scheduling of next day.
- The week will commence from Monday.

d. Availability declaration & Licensee drawal scheduling

- All Generating Stations will declare actual availability on ex-bus basis.
- The Licensees will indicate their drawl schedule at ex-periphery of CEB Transmission System.

e. Procedure for Availability Declaration & Licensee drawal scheduling

1. CEB- Owned Generating Stations

- By 10am each day each CEB-Owned generating station shall furnish ex-bus generation schedule in MW and MU for the next day taking into consideration any outage of its generating unit for the next day, i.e., from 0000 hrs. to 2400 hrs. of the following day in15 minute time blocks in the format provided as **Format-A1 & A2 (Refer Annexure 16.3 & 16.4)**
- By 10am each day, the CEB Owned Hydro Generating Stations to inform availability in the format provided as **Format-A1 & A2 (Refer Annexure 16.3 & 16.4)** . In declaring the MWavailability of hydro stations, CEB shall indicate their reservoir levels, operationalconstraints, and other restrictions along with water management directives report.
- In case if there is fixed value of MW and MWh for all the blocks of day or for number of hours in a day, one figure may be indicated instead of putting block-wise value in the format.
- While declaring actual generating availability CEB shall ensure that the declared availability during peak hours is not less than that during other hours except in case of tripping / re-synchronization of units as a result of forced outage.

2. Independent Power Producers (IPP)

- By 10am, IPP shall furnish ex-bus generation schedule in MW and MU for the next day taking into consideration any outage of its generating unit for the next day, i.e., from 0000 hrs. to 2400 hrs. of the following day in 15 minute blocks in the format provided as **Format-A1 & A2 (Refer Annexure 16.3 & 16.4)**.
- The Generating stations having capacity 1 MW and above, but less than 10 MW shall submit weekly schedule on each Saturday / Sunday for forthcoming week to SCC.
- Generating Stations with less than 1 MW of installed capacity need not to furnish

generation schedule to SCC.

3. Licensee Drawl Schedule

- By 1200 hrs., the SCC shall intimate the Licensee their block-wise MW and MWh energy availability for framing up their drawl schedule in **Format-B (Refer Annexure 16.5)**.
- The Licensee shall review the block-wise energy availability against their block-wise demand for the next day and shall proceed to prepare the drawl schedule.
- If the demand estimate for any 15-minute time block exceeds the energy availability in that block, the drawl schedule shall be considered to be equal to the energy availability of that block.
- Planned load shedding schedule for the day-ahead shall be prepared by the Licensee forsuch 15 minute time block, where the aggregate demand estimate exceeds the energy availability.
- By 1330 hrs., each day, the Licensee shall furnish to the SCC block-wise drawl schedule in the **Format C (Refer Annexure 16.6**) specified by SCC.

Associated documents

- Plant day-ahead availability notices
- Water management directives
- Planned Interruption Schedule to be declared Time Block Wise

Change Record

None

Endorsed for approval

Signature: Designation: SCE, Date:

Approved for Issue by System Control Centre Manager

Signature: Name: Date:

7. Procedure for Day Ahead Hydrothermal Generation Scheduling and Dispatch & Publication

This section sets out the context and background of the assignment.

7.1 Purpose

Develop day ahead schedule using least-cost, security constrained unit commitment and security constrained economic dispatch that optimize energy and reserves.

7.2 Scope

Prepare dispatch Schedule for half an hour interval

7.3 Procedure

a. Preparation of Day-ahead 15 minutes Generation & Drawls Schedule

- By 1500 hrs., each day, the SCC would review the Generation and Drawal Schedule for incorporation of the same in the final schedule to be displayed by SCC.
- While finalizing the requisitions at ex-periphery of generating stations, the SCC would consider the loss figures that would be deducted from ex-power plant for CEB owned generating stations and IPPs.
- By 1700 hrs., each day, SCC shall convey the net drawl schedule at the periphery of the Generating Stations (after deducting the apportioned estimated transmission losses).
- By 1730 hrs., each day, the SCC shall verify the net drawl schedule received from the users with reference to requisitions and deviations.
- By 2130 hrs., each day, the Licensee shall intimate to SCC any revisions to be made in their drawl requisitions already made by them.
- By 2200 hrs., each day, the SCC shall inform the modifications/changes to be made in Generation schedule.
- By 2300 hrs., each day, the SCC shall issue the final generation / drawl schedule.
- The SCC, thereafter, shall convey final generation / drawl schedule to CEB, IPP and Licensees.
- The Performa for conveying drawl schedule to Licensee and generation schedule to Generating Stations is as per **Format-A1 & A2 (Refer Annexure 16.3 & 16.4)** and **Format-B (Refer Annexure 16.5)** respectively.
- The Time frame for "Scheduling Procedure" in sequential order is enclosed subsequently **(Refer Annexure 16.7)**

b. Revision of Schedule

The schedule can be revised during operational day under following events:

- In case of forced outage of a unit for a Generating Station, SCC will revise the schedule on the basis of revised declared availability. The revised schedule will become effective from the 4th time block, counting the time block in which the revision is received by the SCC to bethe first one.
- In the event of congestion in power transmission line, SCC shall revise the schedule which shall become effective from the 4th time block counting the time block in which the transmission constraint has taken place to be the first one. During the first three time blocksalso the schedule shall deemed to have been revised to be equal to the actual generation bythe and drawl by the users.
- In case of any grid disturbance, the schedule generation of all the generating stations and schedule drawl of all the beneficiaries shall be deemed to have been revised to be equal to their actual generation/drawl for all the time blocks affected by the grid disturbance. The exact duration of such grid disturbance would be declared by SCC as the case may be.
- SCC shall permit the revision of declared capability by Generating Units and revision of drawl schedule by Licensee for the remaining period of the day/block. Revised declared capabilityshall become effective from the 6th time block, counting the time block in which the requestfor revision has been received in SLDC to be the first one. The revision shall be not less than a MW capacity to be specified by the SCC.
- If, at any point of time, the SCC of its own observes that there is need for revision of the schedule in the interest of better system operation, it may do so on its own and in such cases, the revised schedule shall become effective from the 4th time block.

c. Implemented Schedule

- SCC uploads daily final implemented schedule on its website for checking / verification by all constituents.
- Within 2 working days after declaring daily implemented schedule, the SCC Manager, shall issue the Final Implemented Schedule (FIS) based on:
    - Actual generation data of CEB Owned Generating stations
    - Actual generation data of IPPs
    - Final Schedule incorporating all revisions and accepted facts changes during day of operation
- SCC shall upload on website the final implemented schedule for information of CEB, IPP and Licensees. Any objections in the schedule will be intimated by the users to SCC within 3 days. Any discrepancy in final implemented schedule issued by SCC shall be brought to his notice by concerned user. SCC shall check and effect rectification wherever required.

Associated documents

- Plant day-ahead availability notices
- Water management directives

- Planned Interruption Schedule to be declared Time Block Wise

Change Record

None

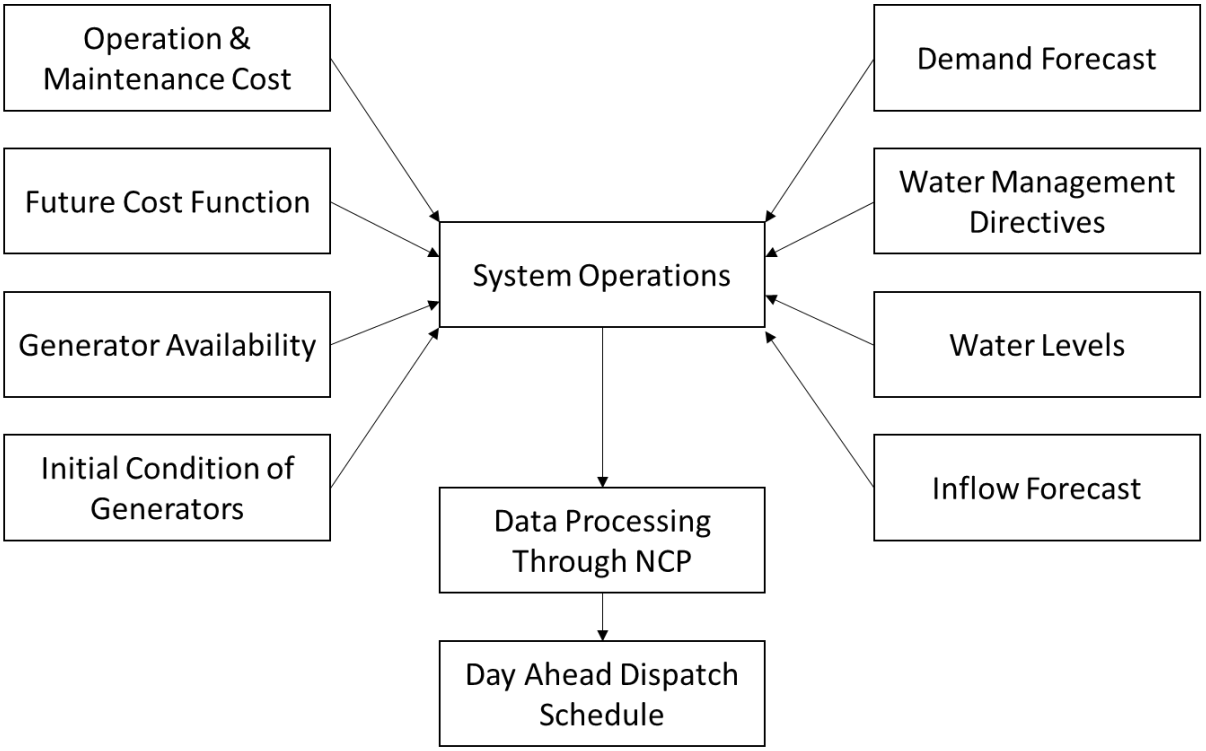
Endorsed for approval

Signature: Designation: SCE, Date:

Approved for Issue by System Control Centre Manager

Signature: Name: Date:

Process Map



Definitions and Acronyms

NCP-

SDDP-Stochastic Dual Dynamic Programming

8. Procedure for Non-declaration of Availability

8.1 Purpose

Monitoring of Non-compliance of terms/conditions/rules outlines under Grid Code.

8.2 Scope

Preparation of procedure for Non-declaration of Availability

8.3 Procedure

- In case on non-declaration of availability within stipulated timeframe as detailed above, by CEB owned Generating Stations or IPPs, SCC would provide a show-cause notice to the defaulter.
- On receiving satisfactory reasons for non-declaration, SCC may allow the Generator to provide for a revised schedule or prepare a schedule on behalf of the Generator for which afee may be paid by generator to SCC
- In case of failure to demonstrate adequate justification for non-declaration, SCC may penalize the Generator through fines (Detailed in Procedure for Non-Compliance to Scheduled Availability)
- In case of repeated non-declaration of availability SCC may revoke the registration of the concerned generator and remove the unit(s) from the Merit Order Stack.
- In case of any establishment of misdeclaration, the availability of each time block of the day will be considered to be reduced proportionately in the ratio of the available capacity established during demonstration and declared capacity.
- In case of more than one misdeclaration, the demonstration which gives the least ratio among the aforesaid ratios will be considered.
- SCC then may introduce fines to penalize the generator for misdeclaration.

Associated documents

- Generator injection Schedule
- Non-Compliance Report

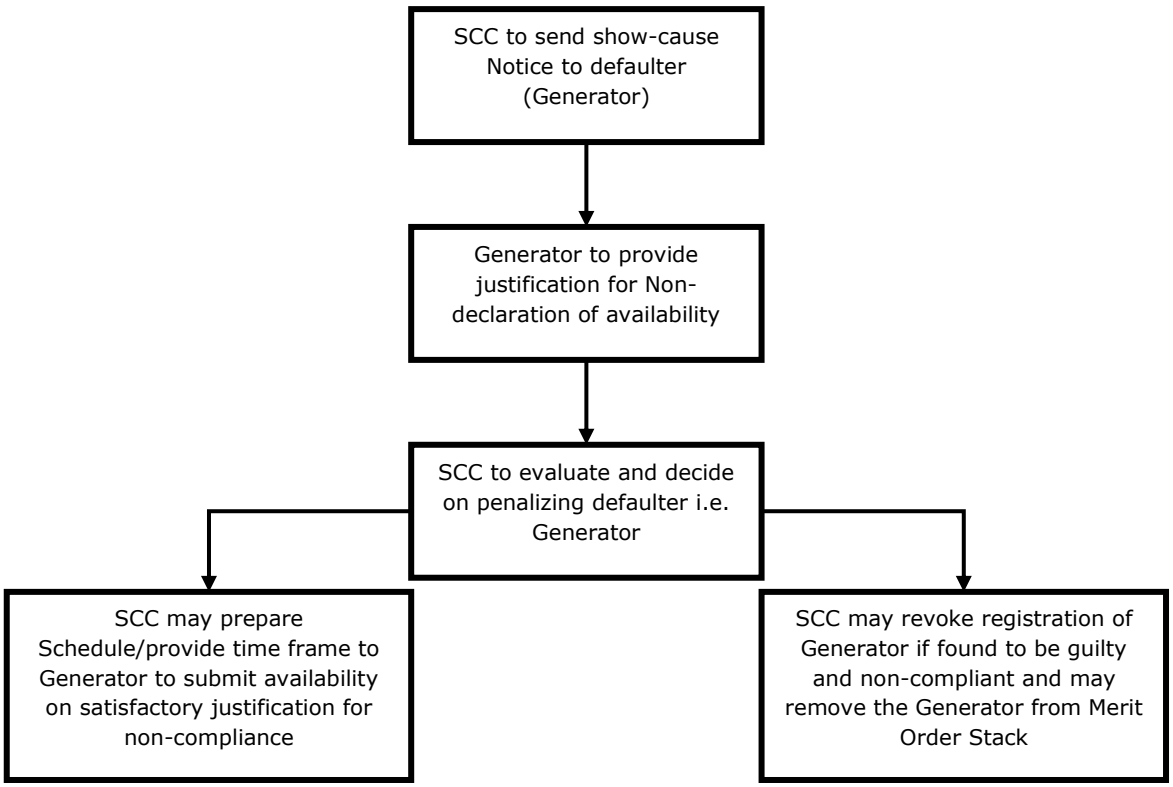
Change Record

None

Endorsed for Approval

Signature: Designation: Date:

Process Map:


SCC to send show-cause Notice to defaulter (Generator)
Generator to provide justification for Non-declaration of availability
SCC to evaluate and decide on penalizing defaulter i.e. Generator
SCC may prepare Schedule/provide time frame to Generator to submit availability on satisfactory justification for non-compliance
SCC may revoke registration of Generator if found to be guilty and non-compliant and may remove the Generator from Merit Order Stack

9. Procedure for Non-compliance to Scheduled Availability

9.1 Purpose

Monitoring of Non-compliance of terms/conditions/rules outlines under Grid Code.

9.2 Scope

Preparation of procedure for Non-compliance to Scheduled Availability

9.3 Procedure

- In case CEB/IPP or Licensee who is required to furnish the Day-ahead Schedule to the SCC,under this procedure, fails to adhere to the schedule, SCC will intimate the same to concerned In-Charges of the defaulters (Generator/Licensee)
- A show-cause notice would then be sent to CEB/IPP or Licensee asking for detailed justifications for failure to comply with the Scheduling procedures.
- On receiving satisfactory reasons for non-declaration, SCC may allow the Generator/Licensee to continue operations.
- In case of failure to demonstrate adequate justification for non-declaration of Schedule, SCCmay penalize the Generator/Licensee through fines.
- In case of repeated offence, SCC may revoke the registration of the concerned generator/Licensee barring the entity from having any access to the power transmission network.
- Fee for preparation of schedule by SCC
    i. If a generating company or a Licensee fails to give its generation or drawal schedule as required and SCC has to prepare a schedule on their behalf, then SCC may charge a fee of Rs. 50,000 (LKR) per schedule for preparing such schedule.
    ii. The SCC may charge a fee of Rs. 10,000 (LKR) per schedule for preparing a schedule onbehalf of a generating company if such generating company under this sub clause fails tofurnish a schedule.
    iii. Generating Stations with less than 1MW of installed capacity need not file its generationschedule with the SCC.

Associated documents

- Generator injection Schedule
- Licensee drawl Schedule
- Non-Compliance Report
- Schedule of Fees and Charges for Non-Compliance

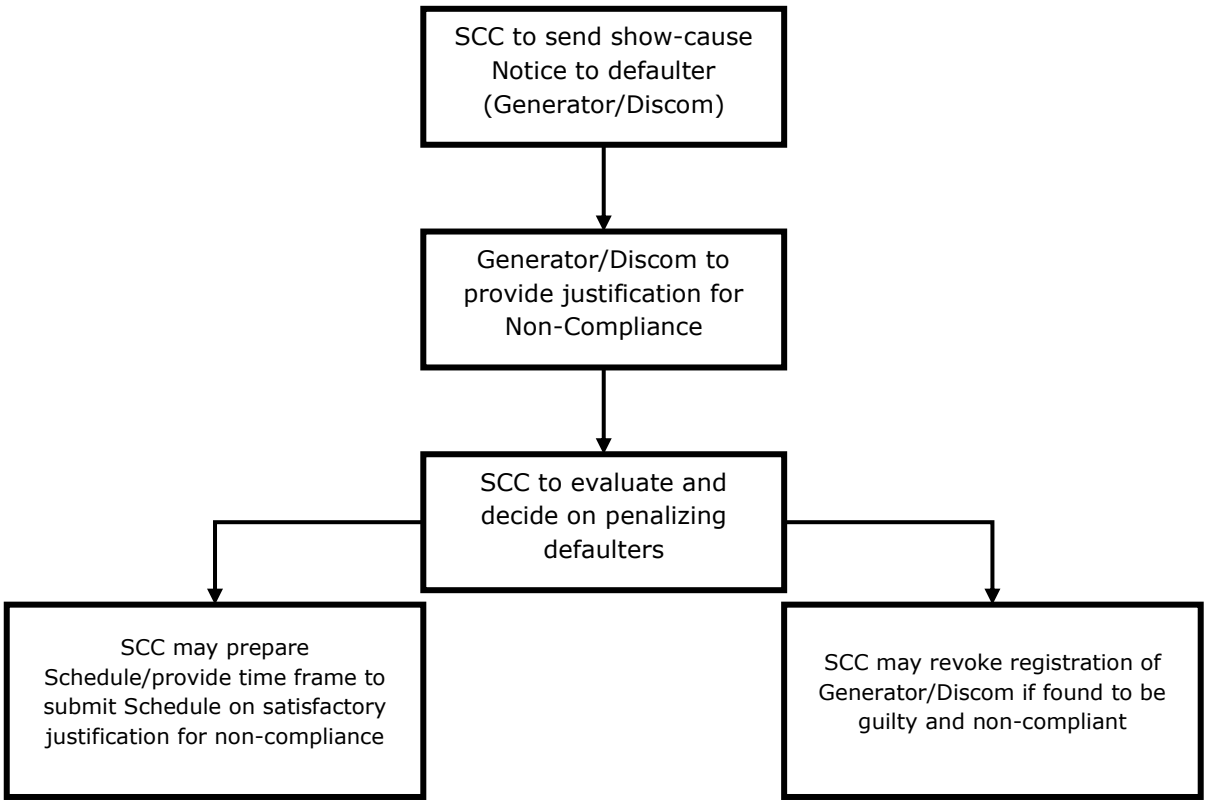
Change Record

None

Endorsed for Approval

Signature: Designation: Date:

Process Map:



10. Procedure for Demand Forecasting

10.1 Purpose

Monthly Energy and Maximum & Minimum demand forecast as input to SDDP

10.2 Scope

Monthly energy and Demand forecast for 20 blocks on monthly basis for next three years

10.3 Procedure

- SCC can consider a combination of time series analysis and end use method, to forecast the electricity demand and electrical energy consumption.
- SCC to review the data used by Distribution Licensee for demand forecasting. The data used can be categorized as under:
    - Monthly Electrical Energy Requirement (MWhr)
    - Monthly Peak Electricity Demand measured in Megawatts (MWhr)
- The licensee are required to submit load forecasts to SCC based on the following categories:
    - A detailed forecast for the year
    - Historical information and data relevant to the load forecast
- SCC to consider Demand Forecasting for final energy needs of consumers belonging to various categories – domestic, commercial, agricultural, industrial, railways, etc.
- After obtaining an estimate of the quantum of energy required at the consumer end, SCC to determine the T&D losses on the basis of past trends and future improvement plans
- Other inputs include the NCRE from integration of Non-Conventional Renewable Energy based Generation into Sri Lanka Power Grid, Three year demand forecast from LTGP
- The format for demand forecasting is attached as **Format-D (Ref: Annexure-16.8)**

Associated Documents

- LGTP prepared by Transmission and Generation Planning branch
- Past 3 years demand readings from Operation Audit section of System Control Branch
- NCRE contribution factors from *"Integration of Non-Conventional Renewable Energy Based Generation into Sri Lanka Power Grid"*

Change Record

Version 1	23/03/2017	First issue

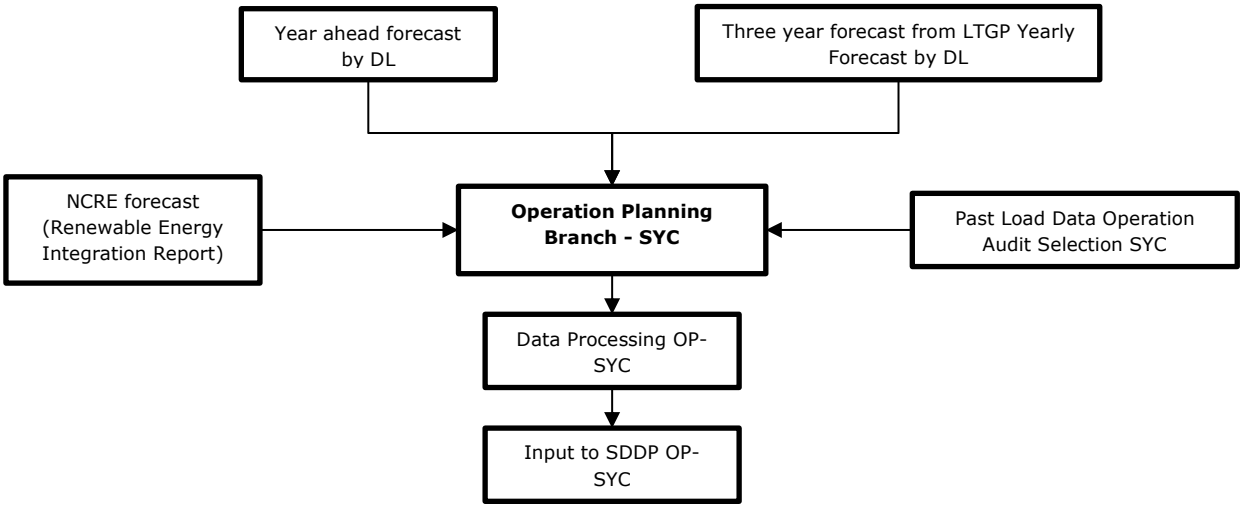
Endorsed for Approval

Signature:	Designation:	Date:

Approved for Issue by System Control Center Manager

Signature: Name: Date:

Process map:



Inputs

1. Year ahead demand forecast
2. Three year demand forecast from LTGP
3. NCRE forecast from integration of Non-Conventional Renewable Energy based Generation into Sri Lanka Power Grid
4. Past Demand Data from OA branches of SYC

Outputs

Twenty block LDC for each month for next three years

Interfaces with other processes

1. DL must submit the year ahead demand forecast by September on each year
2. Published latest version of LTGP is used for three year forecast
3. Latest NCRE document use for NCRE forecast data
4. Past three year demand data shall be available by September on each year

11. Operational Procedure: Water Management Directives

11.1 Purpose

Hydro power plants are dispatched on weekly basis as per the Water Management directives ensuring irrigation and drinking water requirements are met.

11.2 Scope

Weekly Dispatch guideline for hydro power plant operation

11.3 Procedure

- While declaring the availability, hydro Generating Stations shall inform, daily water availability and all other parameters such as reservoir level, restrictions of water usage from National Water Board, overall water quota available for generation.
- In case there is any change in planning for utilization of water during the month, same shall be informed by Generating Station to SCC in advance.
- SCC shall be responsible for operating the hydro power plants on a daily basis considering the month-wise water availability and schedule of the respective Hydro Stations.
- In order to meet system contingencies, SCC may keep hydro capacity equivalent to the capacity of largest thermal Unit as a spinning reserve.

Associated Documents

- Minutes of weekly operational meeting

Change Record

Version 1	23/03/2017	First issue

Endorsed for Approval

Signature:	Designation:	Date:

Approved for Issue by System Control Center Manager

Signature:	Name:	Date:

Inputs

1. Daily water availability
2. Minutes of Weekly water management meeting
3. SDDP simulation outputs
4. Transmission line, hydro plant outages

Outputs

Water management directives

Interfaces with other processes

1. SDDP Dispatch tool
2. NCP Dispatch tool

Resources required

1. MS Excel
2. Operation Planning Engineer

Timetable and publishing

Daily basis

12. Ex-Post Analysis by SCC

12.1 Monitoring the compliance of above procedures

The SCC shall monitor the compliance of the above procedures based on the following:

- Non-compliance of any of the terms/conditions/rules outlines under Grid Code.
- Non-compliance of any of the directives as per the provisions of procedures for Scheduling and Dispatch.
- Providing false information or suppressing material information.
- Failure to provide schedules continuously for 10 days.
- In case of continued default for statutory compliance leading to declaration of willful defaulterby Competent Authority.
- SCC to provide a Summary report to PUCSL regarding the performance of entities for theconcerned year.
- The formats for summary report are provided below in **Annexure-16.**

12.2 Monitoring the Number of Revisions in Schedule

SCC shall monitor the Number of Revisions sent by the Generator / Licensee over the Original Schedule sent to SCC.

12.2.1 Purpose

Monitoring of Non-compliance of terms/conditions/rules outlines under Grid Code.

12.2.2 Scope

Reporting of behavior of entities participating in the Scheduling and Dispatch Process.

12.2.3 Procedure

- SCC to monitor the total number of revisions sent by the Generator / Licensee over the Original Schedule.
- The revision shall be permitted by SCC as laid out in procedure for revision of Schedule.
- SCC holds the right to revise the schedule in the interest of better system operation. This revised schedule shall become effective from the 4th time block and notified to corresponding entities.
- The formats for revision of Schedules for Generator (Thermal/Hydro) and Licensee is attached as **Format-E1, E2** and **E3 (Ref: Annexures 16.9, 16.10 and 16.11)** respectively.

Associated documents

- Plant day-ahead availability notices
- Generator Schedule
- Licensee drawal Schedule
- Water management directives
- Compliance Report

Change Record

None

Endorsed for Approval

Signature: Designation: Date:

Approved for Issue by System Control Center Manager

Signature: Name: Date:

12.3 Real Time Injections vs Projections Shared and Variance Analysis

12.3.1 Purpose

Monitoring of Non-compliance of terms/conditions/rules outlines under Grid Code

12.3.2 Scope

Reporting of behavior of entities participating in the Scheduling and Dispatch Process

12.3.3 Procedure

- SCC to monitor the actual energy injection by Generator on daily basis and compare with the projected injection schedule.
- The variance analysis conducted would be considered to rectify the input parameters for better and more accurate energy requirement forecasting.
- The formats for daily reporting and variance analysis are attached as **Format-F (Ref: Annexure- 16.12).**

Associated documents

- Plant day-ahead availability notices
- Generator Schedule
- Water management directives
- Compliance Report

Change Record

None

Endorsed for Approval

Signature: Designation: Date:

Approved for Issue by System Control Center Manager

Signature: Name: Date:

12.4 Real Time Drawal vs Projections and Variance Analysis

12.4.1 Purpose

Monitoring of Non-compliance of terms/conditions/rules outlines under Grid Code

12.4.2 Scope

Reporting of behavior of entities participating in the Scheduling and Dispatch Process

12.4.3 Procedure

- SCC to monitor the actual energy drawal by Licensee on daily basis and compare with the projected drawal schedule.
- The variance analysis conducted would be considered to rectify the input parameters for better and more accurate forecasting.
- The formats for daily reporting and variance analysis are attached as **Format-G (Ref: Annexure-16.13).**

Associated documents

- Licensee drawal Schedule
- Compliance Report

Change Record

None

Endorsed for Approval

Signature: Designation: Date:

Approved for Issue by System Control Center Manager

Signature: Name: Date:

12.5 Preparation of Monthly Summary report

12.5.1 Purpose

Monitoring of Non-compliance of terms/conditions/rules outlines under Grid Code

12.5.2 Scope

Reporting of behavior of entities participating in the Scheduling and Dispatch Process

12.5.3 Procedure

- SCC to prepare a consolidated report on monthly basis to monitor the actual energy injection/drawal by Generator/Licensee and compare with the projected energy injection/drawal schedule.
- The variance analysis conducted would be considered to rectify the input parameters for better and more accurate forecasting.
- SCC to prepare the final summary report prepared for reporting to PUCSL.
- The formats for the summary report for Generator and Licensee are attached as **Format-H1 & H2 (Ref: Annexure- 16.14 and 16.15)** respectively**.**

Associated documents

- Generator Schedule (daily basis)
- Licensee daily drawal Schedule
- Compliance Report

Change Record

None

Endorsed for Approval

Signature: Designation: Date:

Approved for Issue by System Control Center Manager

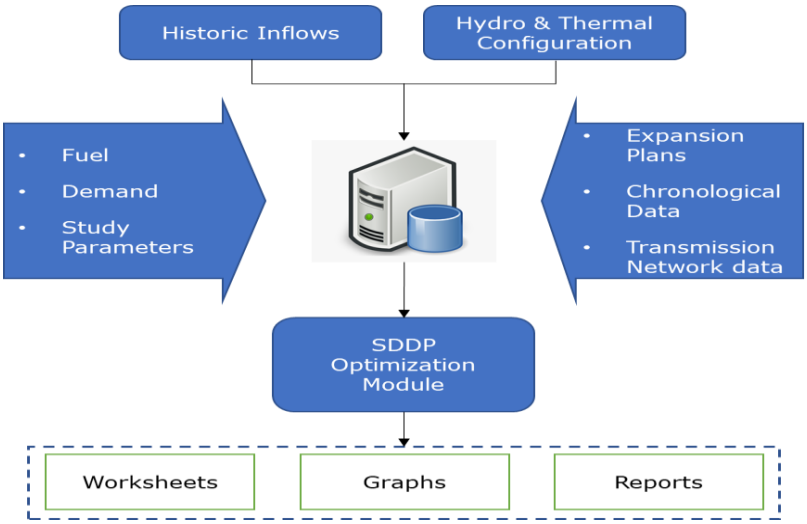
Signature: Name: Date:

13. Global Best Practices for SDDP

13.1 Introduction- Basic functions carried out using SDDP

The System Control Center (SCC) uses SDDP version 16 for medium to long term operational planning activities. The execution of operational activities, input data are all linked together through multiple SDDP modules. A basic data execution in SDDP is represented below:

Figure 28:Basic Workflow in SDDP



13.2 Best Practices of use of SDDP

The following refer to some best practices of using SDDP that is accepted globally to improve the model performance.

13.2.1 Frequency for Forecasting

Globally, in terms of frequency for forecasting, SDDP is used to carry out – year ahead, month ahead and week ahead planning processes. In most advanced countries, the Regulator is normally responsible for creating the awareness regarding the adoption of best practice tools for proper forecasting and specifying the planning processes with the Load Despatch Centre carrying out the execution of the processes. The SCC can adopt the following forecasting framework:

Year Ahead Plan	Month Ahead Plan	Week Ahead Plan
• The document includes plan for generation on monthly basis for each power project (hydro / thermal). • Details of hydro reservoir levels, water values, plant maintenance and outage schedules are included for setting baseline forecasts	• Used to show monthly mean, upper/lower values in percentiles. • Objective is to be able to further simulate month ahead plans to hourly plans to identify differences in hourly contracts for the Single Buyer and take appropriate measures as part of long term planning	• Uses SDDP simulation results to directly influence the generation market and actual plant operations. • SDDP is used to calculate water values and target storage levels for large reservoirs. • Water values could be obtained from this simulation, along with reservoir end of week storage targets

13.2.2 Requirment of Additional years for Optimization of SDDP outputs

During the planning process, it is recommended that additional years are considered in SDDP modelling to get the optimized output. A global practice as per an earlier World Bank study states that two additional years is generally ample for SDDP optimization. However, to ensure that the adequate number of additional years is considered is to add another year to the SDDP computations and check variability of the forecasts. In case of minor variations, the optimum number of years are considered to be achieved.

13.2.3 Back Testing of SDDP

Back testing of simulation models is encouraged as an institutional process. Globally load dispatch operators consider them as extremely useful in identifying inconsistencies / shortcomings in plant input data and the extent to which the modelling process represents the actual system operation. The main objective is to achieve optimal schedules via SDDP and ensure congruity with real world scenarios. A back test of SDDP should preferably be performed whereby SDDP is used to simulate a past year.

As a good industry practice usually adopted globally across load dispatch operators, the back test should preferably be carried out for any the three planning tasks carried out by SDDP.

- The year ahead plan uses a single inflow sequence for the year so will clearly deviate from actual results due to inflows variability.
- The month ahead plan comparison would be affected by actual inflows differing from those modelled.
- The week ahead plan, a type of mean reversion inflow forecast is used, taking account of the previous 10 days' inflows. These flows are more likely to resemble actual inflows.

It is recommended to compare the inflows forecast for the next week against actuals for a full year. There are at least two possible ways this test could be carried out:

1. Perform a stochastic optimisation for the year and then simulate with actual inflows.
2. Run a deterministic optimisation, using actual inflows.

The results of a stochastic optimisation would result in the simulation carried out using actual inflows following a different path to what was done in reality. Further a variance analysis of planned and

actual values for reservoir levels and inflows can give insights into the dispatch planning process and measures that can be taken for reducing the inconsistencies in the model.

13.2.4 Stochastic Optimisation

CASE STUDY: *A back test was performed by Parsons Brinckerhoff as a part of their World Bank project for hydro modelling using SDDP software. Their report also describes that back testing of data showed reasonable results and that differences in simulated and actual outcomes could be explained. This back test indicated that the SDDP model is producing results that were reasonable.*

The SDDP software can be configured to run in both deterministic and stochastic mode. It is recommended to follow stochastic optimisation method in SDDP to get more realistic results and eliminating the variance between planned and actual values. The manual shared by CEB for SDDP also showcases procedures under Stochastic Mode and it is recommended that the SCC continue to run the software with stochastic optimization.

As mentioned earlier, the frequency for undertaking SDDP forecasts and reporting should be as per follows:

13.2.4.1 Year ahead report

The Year Ahead report should encompass the following

- Consists of annual summaries of plant output and performance in graphical form.
- The report generated using stochastic optimization can be used to show annual mean, upper/lower values in percentiles.
- Graphical outputs generated can show weekly mean and weekly upper/lower percentiles.

13.2.4.2 Month ahead report

The Month ahead report will incorporate the following

- The report generated using stochastic optimization can be used to show monthly mean, upper/lower values in percentiles.
- The month ahead plan is not used for real time operations planning so it does not have to be accurate in every detail.

13.2.4.3 Week ahead report

The Week ahead report should have the following coverage

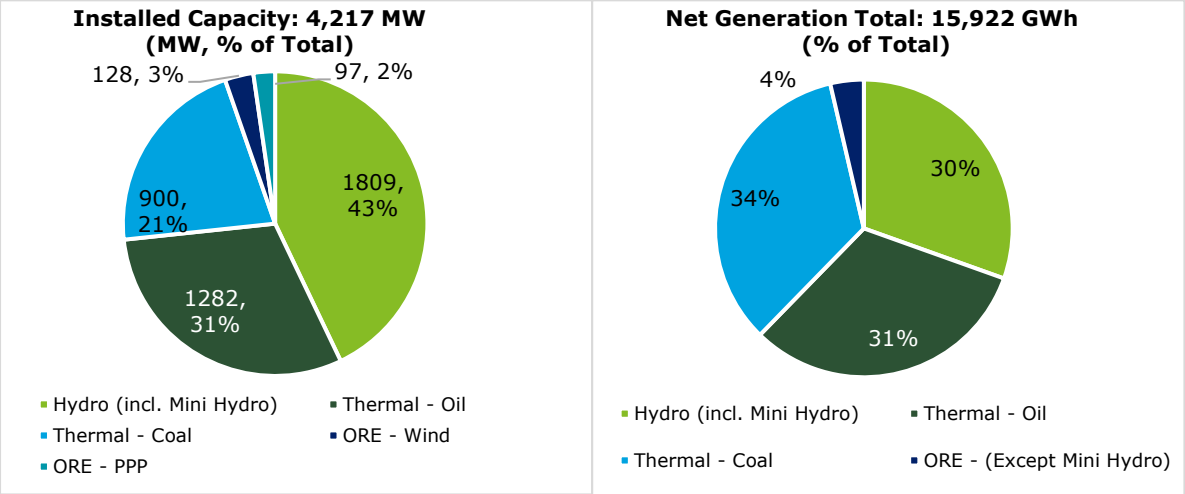
- Stochastic optimisation as applied for month ahead process could be used to present week ahead inflow forecast.
- The simulation can be performed for the entire week ahead, using the best possible inflow forecast.
- Water values could be obtained from this simulation, along with reservoir end of week storage targets.

- Detailed hourly plan for the week ahead can be calculated reservoir levels from SDDP as target levels.

13.2.4.4 Inflow forecasting

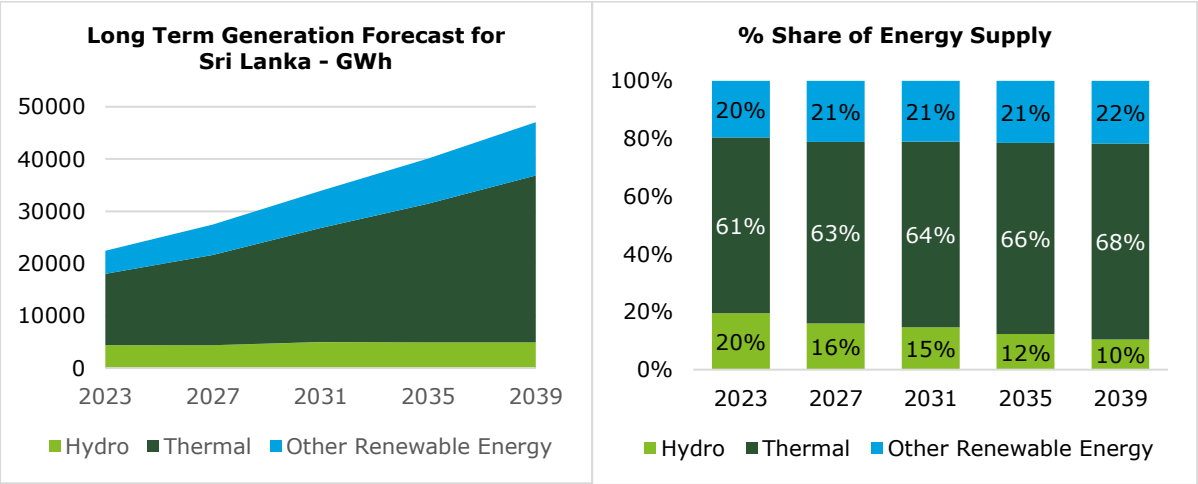
The total power sector installed capacity in Sri Lanka at the end of FY2019 was 4,217 MW which was dominated by Hydro and thermal-oil based power plants[4]. Both Hydro and thermal-oil contribute ~43% and ~31% in terms of installed capacity for the country. The share of Hydro power plants in the dispatched energy into the electrical system is also high at 30%[5].

Figure 29: Installed Capacity & Net Generation in Sri Lanka (FY2019)



However, as per the CEB's Long Term Generation Forecast, Sri Lanka is expected to increase their share of thermal as well as Renewable Energy in the power supply mix to supplement their rapidly growing energy demand. Renewable energy (excluding Hydro) is expected to increase to ~20% in the future.

Figure 30: Long term forecast and share of energy supply till FY2039



The variability of Renewable Energy generation requires grid stability interventions. Hydropower is increasingly being sought after as a Grid Integration solution for some of the VRE challenges as its

[4] Source: Statistical Yearbook 2019
[5] Note: ORE in the graphs represent – Other Renewable Energy Sources

inherent flexibility in the power system helps fill the gap generated due to fluctuations between electricity supply and demand. The storage capabilities of many hydropower plants help in optimizing the use of variable RES over shorter and longer periods. Thus, considering the hydro power supply in Sri Lanka as well as the plan for increasing Renewable Energy Generation there is a need to focus on inflow forecasting for SDDP simulations and optimization of load despatch procedures.

The inflow forecasting process should include close coordination with water management boards to obtain weekly flow data for hydro plants. The data should be analysed with the generators to derive the following key inputs for SDDP:

- Net inflow (m3/s)
- Reservoir water surface elevation at 0:00 hour (m).
- Outflow (m3/s)
- Spill (m3/s)
- Energy generation (MWh)

To apply effective inflow forecasting for the Sri Lankan Electricity Market using stochastic optimisation, the simulation can be adjusted by fitting a simple model to the historical data for each site representing the rate at which inflows revert to a base flow level at various times of the year.

A statistical modelling process can be used to create weekly data to represent the true weekly data, to the extent possible. The basic parameters needed by SDDP for each site include

- Weekly mean,
- Weekly auto correlation,
- Standard deviation of inflows,
- Weekly mean patterns; and
- Spatial correlation.

13.2.4.4.1 Process Improvement

The following measures are suggested for improving the inflow forecasting:

- SCC can calculate the weekly inflow data from data received from hydro plants.
- SCC can co-ordinate with the 'Mahaweli Authority' and 'The National Water Board' to locate raw data for sites prior to construction of hydro projects. The flow data are available directly from river gauging records or through scaling of flows using a gauging station.
- A web based tool should be used to obtain and collate the flow data from the gauging stations. Such data should be applied on an analytical layer to correlate and develop suitable forecasting algorithms
- All flow data should be reviewed for consistency, for periods before and after commissioning.

13.2.5 SDDP Training

It is further recommended that an annual training plan should be introduced for SDDP software for SCC as well as PUCSL officials to ensure that both the Load Despatch Centre and Regulator are in concurrence of the customizations made to the SDDP software considering the uniqueness of the Sri Lankan Electricity Market.

13.3 Recommendations

1. Periodic Back testing of SDDP is recommended to check and fine tune the data in the model considering the nuances of Hydropower dispatch procedures in the Sri Lankan Power Market. Awareness about Back testing should be built up at SCC with periodic review of the back test results to identify variances and scope for further optimization. An annual back testing practice should be established at SCC as part of the Ex-post Analysis Reporting to PUCSL
2. The outcomes of the back testing may be utilized to consider suitable tuning of SDDP parameters with due consideration for the energy mix and load requirement of the Sri Lankan Electricity Market to improve the speed and accuracy of solution
3. Planning process specifications should be periodically reviewed and revised to require the use of stochastic optimisation for all processes based on the extent of identification of gaps and enhancements required.
4. Specific planning functions could be modified to accommodate stochastic solution:
    - For the year ahead plan, the mean result of a stochastic study could be presented, along with upper and lower ceiling percentile values, i.e. three sets of tables of values, instead of the present one set. Extreme maximum and minimum values can also be considered.
    - Month ahead planning could be done using stochastic optimisation with the indicative hourly results obtained from SDDP using the hourly results mapping function.
    - For the week ahead plan, water values and reservoir targets could be obtained from an SDDP simulation of the next week using the best inflow forecasting method available.
5. It is recommended to use weekly inflow data, rather than the monthly data. This can be achieved by:
    - Calculating weekly data values required for operating hydro plants. SCC receives the required data from Hydro Plants on regular basis.
    - The inflow forecasting process should include close coordination with water management boards to obtain weekly flow data for hydro plants. The data should be analysed with the generators to derive the following key inputs for SDDP:
        - Net inflow (m3/s)
        - Reservoir water surface elevation at 0:00 hour (m).
        - Outflow (m3/s)

- Spill (m3/s)
- Energy generation (MWh)

6. Improved forecasting of week ahead inflows should be investigated. This is likely to require separately calibrating a model for each catchment to take account of the geography of each.
7. It is recommended that an annual and bi-annual exercise may be conducted by PUCSL with SCC staff to cross-check and propose adjustments to the simulations carried out by SCC. PUCSL may also conduct third party reviews of SCC's calculation from external bodies, consultants etc.
8. An annual training plan should be introduced for SCC and PUCSL officials on use of SDDP software and the customizations being made in the software for Sri Lankan Electricity Market.

14. Compliance to Dispatch Audit Guidelines

14.1 Audit Steps, Responsibilities of SCC and PUCSL and Timeline for Audit

The dispatch audit shall be carried out annually by PUCSL after the completiin of the financial year that is to be audited. It is recommended that SCC follows the Disptach Audit Guidelines as per the procedure and timeline mentioned below. The audit timetable has been aptly adjusted so as to avoid excessive resources being committed to the audit and to provide sufficient time for SCC to act in response to audit findings before the next audit takes place. The dispatch audit steps and timelines along with the responsibilits of SCC is provided below.

Table 10: Audit Steps, Responsibilities of SCC and PUCSL and Timeline for Audit

Sl. No.	Audit Steps	Responsibilities of SCC and PUCSL	Timeline
1	**Performance self-assessment**	SCC shall provide PUCSL with a self-assessment report of its performance for the preceding year. It shall include comparison of actual performance and targeted performance and variance analysis.	**28th February**
2	**Submission of procedures**	Along with the Self-Assessment Report, SCC shall provide PUCSL with a comprehensive description of all current operating procedures along with changes made from previous. In case of absence of operating procedures, SCC shall provide PUCSL with an explanation of the reasons for their non-availability.	**28th February**
3	**PUCSL initial review**	PUCSL shall review the self-assessment report and operating procedures and identify areas of concern for follow-up. PUCSL shall assess the compliance of previous audit and provide recommendations for improvements.	**1-15th March**
4	**Further investigation**	Following the initial review, PUCSL shall inform the SCC the areas for concern and identify those that requires further investigation. PUCSL may require SCC to provide additional data related to these areas of concern.	**15th March**
5	**Site visit**	PUCSL staff shall conduct site visits to SCC, meet with management and discuss the identified areas of concern and obtain additional data if required. During this site visit, SCC will be expected to provide responses to PUCSL on the identified areas of concern, including:	**31st March**

Sl. No.	Audit Steps	Responsibilities of SCC and PUCSL	Timeline
		• Providing the latest documented operating procedures for the identified areas of concern. • Explaining the operating procedures in detail, where appropriate, and provide supporting evidence on random selected data set to demonstrate that the relevant operating procedures are followed. • Explaining in more detail (than included in the self-assessment report) the reasons for under-performance. • Explaining what SCC will do to address these causes of under-performance. • Identifying what further steps, if any, can be taken by entities other than SCC	
6	**Draft audit report**	Following the initial review and site visit, PUCSL will prepare a draft report on its findings from the audit and recommend actions to address areas of concern.	**15th April**
7	**SCC responses**	PUCSL will provide its draft audit report to SCC for review and responses. SCC's shall address the comments /areas of concern and provide in writing to SCC what actions it is taking or plans to improve performance.	**30th April**
8	**Final audit report**	The final audit report incorporates PUCSL's findings from audit and provides recommendations to address areas of concern.	**15th May**

The results and recommendations contained in the final report shall serve as a basis for creating the work programme during the year by SCC, PUCSL and other entities depending on the nature of the programme. PUCSL shall monitor the compliance of the Audit Procedures and adherence to the timelines. The final report, after removal of any confidential data, shall be made publicly available on both PUCSL and SCC's websites, as per the timetable specified above.

15. Way Forward

15.1 Next Steps

- Obtaining feedback from stakeholders on our findings and incorporate the same to formulate our recommendations.
- Based on the above, documentation of final revised procedures and reporting / disclosure templates in Final Report.

16. Annexures

16.1 Training & Capacity Building Activities at ERLDC

Table 11: Training & Capacity Building Activities at ERLDC, India

Name of Program		Objective
System Operation	Frequency Control and Reserves	The participants are made aware about the different methods of frequency control and allocation/assessment of reserves for these control methods
	Power System Studies on PSSE & Python Programming for PSSE	The Participants are familiarised with steady state, dynamics, and short circuit studies in PSSE. They will also acquire basic knowledge of using python language for automation in PSSE.
	Basic Level Training on PSCAD	The participants are familiarised with PSCAD software and its use for system operators in analysing power system transients
	Demand and RE Forecasting & Renewable Integration	The participants are made aware about techniques for demand and RE forecasting. This program will also focus on the issues and challenges for renewable integration
	Advances in Power System Visualisation	The participants are made aware about different visualisation techniques and advances worldwide in this regard.
	PMU Analytics and WAMS	The participants will be made aware about the basics of PMUs/ WAMS and different types of PMU based analytics for Power System Operation.
Market Operation	Financial Products in Electricity Market	The participants are familiarised with the principles of Financial Products in Electricity Market. Need for Financial Contracts Basic Principles of Risk Management Fundamentals of Forward Contracts and Future Contracts Hedging -Basic Principles, Properties and Strategies Legal and Regulatory Framework for upcoming financial products
	Metering and Settlement Systems	The participants are familiarised with the fundamentals of metering and settlements system and existing practices in India.
	Electric Vehicle and Storage Technologies	The participants have an understanding of various electric vehicles and storage technologies Storage devices / EVs in India Market for the Growth of EVs
	Transmission Pricing	The participants will understand various aspects related to Transmission Pricing.
	Open Access Administration	The participants understand various aspects related to Open Access and transactions. Overview of the Regulatory Framework Types of Open Access Transactions
SCADA & IT	IT in System Operation	The participants are able to understand use of IT in System Operation, SCADA, and Communication Network Overview
	Workshop on Info. Security & Cyber Crisis Management	The participants are able to understand issues related to cyber security and how security of IT systems can be ensured.

	Basic Program on SCADA & EMS	RTU Basics / Data Acquisition Principles, Alarm and Quality Flags SCADA Features and Database -Modelling
Renewable Energy Certification	Renewable Energy Sources and Grid Integration	Issues and Challenges pertaining to Integration of Renewable Energy, Technical and Operational Imperatives, REC Mechanism and implications, Regulatory Framework, Commercial Mechanisms for integration, Road Map ahead
	Integration of Renewables	Knowledge on Status of Renewable Energy Technology Renewable Resources Assessment & Techniques Economic analysis of Renewable Energy Power Projects
	Renewable Energy Certificate Mechanism	The participants understand various issues related to REC Mechanism.
Finance	Strategic Finance Workshop	The participants are able to enhance their skills that help the organisation to optimise financial strategies and develop new opportunities for success in a given learning environment
	Finance for Non-Finance	The participants get exposure in the area of finance and accounts, so that all basic concepts of finance including analysing the financial statements, budgeting, etc. are understood from general perspective.
Behavioural, Health and Leadership	Team Building: Experiential Learning Workshop	How to interact and communicate with each other Importance of trust, communication, and transparency.
	Improving Interpersonal Skills and Emotional Intelligence	Developing and enhancing Interpersonal Relationship and Communication Skills, Increased understanding of how both conscious actions and unconscious reactions define our behaviour toward others
	Art of Living	The participants develop understanding about improved inter-personal relationships and teamwork; improved work efficiency; positive attitude and disposition; and for rejuvenation and relaxation
	Women Wellness	The participants are able to understand their statutory rights, privileges; find solutions to common work-life challenges
General Workshops	Sexual Harassment of Women at Workplace	The participants are equipped with the knowledge on the subject to prevent sexual harassment and develop in them professional competence for implementation of the statute and also to enhance knowledge of participants resulting in an increased level of appreciation for diversity and become familiar with workplace diversity; to learn how diversity issues impact us in our daily interaction and in the workplace.
	Workplace Ergonomics, Safety and First Aid	Knowledge on First Aid & CPR, Health and Safety procedures. Workplace Ergonomics and improving efficiency through ergonomics, Ergonomics Audit of the office premises
	Work Ethics, Preventive Vigilance and RTI Act	Knowledge about ethics in Governance, Disciplinary proceedings, Pro-active Vigilance, Preventive Vigilance, Punitive Vigilance, Predictive Vigilance, Participative Vigilance

16.2 Training & Capacity Building Activities at PGCB

Table 12: Training & Capacity Building Activities at PGCB, Bangladesh

Subject of Training	Target Group	Objective
Enterprise Resource Planning (ERP) Software (Online)	JAM to DGM	Knowing real time information about business field strategies. It helps in better planning and proper management of resources
Effective Communication Skills (Online)	AM to Manager	Enable participants to communicate clearly and with impact, by improving their verbal and non-verbal communication style, as well as enhancing interpersonal skills.
Strategic Management & Competitive Advantages (Online)	XEN/Manager to CEIGM	Understanding basic planning, forecasting techniques for effective control over factors effecting daily operations
Ethics & integrity (Online)	OA/AA/SA/PS	Ensures an organization lives its common values and principles.
Operation and Maintenance of Grid Substation (Online)	SDE/AE	Update staff and personnel on Substation Types, Applications, Components and Safety Procedures, Maintenance and Testing Methods for Medium-Voltage Circuit Breakers, Switchgear Arrangement, Torque Requirements, Insulation Systems and Maintenance Intervals
Fundamentals of ICT (Online)	OA, PS, SA, AA, JAM/SAE	Deepen the knowledge of technology, understanding of topics related to computer science and web development which impacts daily operations at the Control Room
Renewable Energy Sources and Grid integration (Online)	AE to SE	Strong understanding of power systems, their operation and control with focus on the issues related to the integration of (DER) i.e. distributed renewable generation into the network creating a strong foundation for power system equipments used for integration.
Bangladesh Labour Laws & Labour Rules	LMIFM/Eect/SAE/JAM	Update the personnel on labor laws and rules and standard practices at office premises.
Fire, Earthquake & Disaster Management	SAE	Create awareness related to safety standards. procedures and increase response time of employees in case of emergence situations
Primary Frequency Control, Secondary Frequency Control, Tertiary Frequency Control	SAE to SE	Aimed at better grid management, improving the reliability of grid, and maintaining grid security.
Transmission Line and Respective Bay Equipment Commissioning (On Job)	LM/FM/TA/ELECT/SAE	Improve the knowledge of technical staff on General Duties& Responsibilities at substations so that his/her conceptions are quite clear about the work that has to be carried out.
Skill improving Training Course for Officers (Online)	SDE/AEISAE	Provide job related knowledge to the workers, impart skills among the workers systematically so that they may learn quickly and to bring about change in the attitudes of the workers towards fellow workers, supervisor, and the organization
Good Governance & National integrity Strategy (NIS)-(Online)	AE/AM to DGM/SE	Promote the implementation of governance measures such as Information Disclosure and public hearing systems in local areas.
Modern SCADA and Security System (Online)	SDE to SE	Aimed at understanding designing, commissioning, and maintaining the security Control Systems

16.3 Format-A1

Generating Station Ex-bus Declared Capability (THERMAL)

(To be furnished by each Generating station to SCC at 10.00 hrs. each day on day ahead basis

		Peak Hours	Off-Peak Hours
Name of Generating Station		Operational Capacity / Declared Capacity (MW)	
Schedule for date		Date of Submission	
Installed-Name Plate Capacity (MW)		Time of Submission	
Derated Capacity (MW)			

Reason for Non-Available Capacity for Peak and Off Peak Hour:*

*Reason for Non-Availability to be provided with Water Management Directives

Block No.	Block Time		Unit No.1		Unit No.2		Unit No.3								Total	
			MW	MWh	MW	MWh	MW	MWh							MW	MWh
1	00:00	00:15														
2	00:15	00:30														
3	00:30	00:45														
4	00:45	01:00														
5	01:00	01:15														
6	01:15	01:30														
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32	07:45	08:00														
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69	17:00	17:15														
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71	17:30	17:45														
72	17:45	18:00														
73	18:00	18:15														
74	18:15	18:30														
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76	18:45	19:00														
77	19:00	19:15														
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81	20:00	20:15														
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87	21:30	21:45														
88	21:45	22:00														
89	22:00	22:15														
90	22:15	22:30														
91	22:30	22:45														
92	22:45	23:00														
93	23:00	23:15														
94	23:15	23:30														
95	23:30	23:45														
96	23:45	00:00														
Total (In Mus)																

Signature & Name:

(In-Charge Scheduling)

16.4 Format-A2

Generating Station Ex-bus Declared Capability (HYDRO)

(To be furnished by each Generating station to SCC at 10.00 hrs. each day on day ahead basis

Name of Generating Station		Operational Capacity / Declared Capacity (MW)	Peak / Off-Peak
Schedule for date		Storage (m3)	Maximum / Minimum
Installed-Name Plate Capacity (MW)		Turbine inflow and outflow (m3/s)	Inflow / Outflow
Derated Capacity (MW)		Reservoir Level (m)	Maximum / Minimum

Block No.	Block Time		Unit No.1		Unit No. 2		Total	
			Plant Name		Plant Name		Plant Name	
			MW	MWh	MW	MWh	MW	MWh
1	00:00	00:15						
2	00:15	00:30						
3	00:30	00:45						
4	00:45	01:00						
5	01:00	01:15						
6	01:15	01:30						
7	01:30	01:45						
8	01:45	02:00						
9	02:00	02:15						
10	02:15	02:30						
11	02:30	02:45						
12	02:45	03:00						
13	03:00	03:15						
14	03:15	03:30						
15	03:30	03:45						
16	03:45	04:00						
17	04:00	04:15						
18	04:15	04:30						
19	04:30	04:45						
20	04:45	05:00						
21	05:00	05:15						
22	05:15	05:30						
23	05:30	05:45						
24	05:45	06:00						
25	06:00	06:15						
26	06:15	06:30						
27	06:30	06:45						
28	06:45	07:00						
29	07:00	07:15						

30	07:15	07:30						
31	07:30	07:45						
32	07:45	08:00						
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35	08:30	08:45						
36	08:45	09:00						
37	09:00	09:15						
38	09:15	09:30						
39	09:30	09:45						
40	09:45	10:00						
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44	10:45	11:00						
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66	16:15	16:30						
67	16:30	16:45						
68	16:45	17:00						
69	17:00	17:15						
70	17:15	17:30						
71	17:30	17:45						
72	17:45	18:00						
73	18:00	18:15						
74	18:15	18:30						
75	18:30	18:45						

76	18:45	19:00						
77	19:00	19:15						
78	19:15	19:30						
79	19:30	19:45						
80	19:45	20:00						
81	20:00	20:15						
82	20:15	20:30						
83	20:30	20:45						
84	20:45	21:00						
85	21:00	21:15						
86	21:15	21:30						
87	21:30	21:45						
88	21:45	22:00						
89	22:00	22:15						
90	22:15	22:30						
91	22:30	22:45						
92	22:45	23:00						
93	23:00	23:15						
94	23:15	23:30						
95	23:30	23:45						
96	23:45	00:00						
Total (In Mus)								

Reason for Non-Available Capacity for Peak and Off Peak Hour:* _____

*Reason for Non-Availability to be provided with Water Management Directives

Signature & Name:

(In-Charge Scheduling)

16.5 Format-B

Distribution Licensees Drawal Schedule
(To be Displayed by SCC at 12.00 hrs. each day on day ahead basis)

Date of Submission:
Time of Submission:

Name of distribution Licensees/ Licensee			
Schedule for date			
Block No.	**Block Time**		**Total Drawal (MWh)**
1	00:00	00:15	
2	00:15	00:30	
3	00:30	00:45	
4	00:45	01:00	
5	01:00	01:15	
6	01:15	01:30	
7	01:30	01:45	
8	01:45	02:00	
9	02:00	02:15	
10	02:15	02:30	
11	02:30	02:45	
12	02:45	03:00	
13	03:00	03:15	
14	03:15	03:30	
15	03:30	03:45	
16	03:45	04:00	
17	04:00	04:15	
18	04:15	04:30	
19	04:30	04:45	
20	04:45	05:00	
21	05:00	05:15	
22	05:15	05:30	
23	05:30	05:45	
24	05:45	06:00	
25	06:00	06:15	
26	06:15	06:30	
27	06:30	06:45	
28	06:45	07:00	
29	07:00	07:15	
30	07:15	07:30	
31	07:30	07:45	
32	07:45	08:00	
33	08:00	08:15	
34	08:15	08:30	

35	08:30	08:45	
36	08:45	09:00	
37	09:00	09:15	
38	09:15	09:30	
39	09:30	09:45	
40	09:45	10:00	
41	10:00	10:15	
42	10:15	10:30	
43	10:30	10:45	
44	10:45	11:00	
45	11:00	11:15	
46	11:15	11:30	
47	11:30	11:45	
48	11:45	12:00	
49	12:00	12:15	
50	12:15	12:30	
51	12:30	12:45	
52	12:45	13:00	
53	13:00	13:15	
54	13:15	13:30	
55	13:30	13:45	
56	13:45	14:00	
57	14:00	14:15	
58	14:15	14:30	
59	14:30	14:45	
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61	15:00	15:15	
62	15:15	15:30	
63	15:30	15:45	
64	15:45	16:00	
65	16:00	16:15	
66	16:15	16:30	
67	16:30	16:45	
68	16:45	17:00	
69	17:00	17:15	
70	17:15	17:30	
71	17:30	17:45	
72	17:45	18:00	
73	18:00	18:15	
74	18:15	18:30	
75	18:30	18:45	
76	18:45	19:00	
77	19:00	19:15	
78	19:15	19:30	

79	19:30	19:45	
80	19:45	20:00	
81	20:00	20:15	
82	20:15	20:30	
83	20:30	20:45	
84	20:45	21:00	
85	21:00	21:15	
86	21:15	21:30	
87	21:30	21:45	
88	21:45	22:00	
89	22:00	22:15	
90	22:15	22:30	
91	22:30	22:45	
92	22:45	23:00	
93	23:00	23:15	
94	23:15	23:30	
95	23:30	23:45	
96	23:45	00:00	
Total In MWh			

Signature & Name:
(In-Charge Scheduling)

16.6 Format-C

Distribution Licensees Drawl Schedule
(To be Displayed by Distribution Licensee at 13.30 hrs. each day on day ahead basis)

Date of Submission:
Time of Submission

Name of distribution Licensees/ Licensee			
Schedule for date			
Block No.	**Block Time**		**Total Drawal (MWh)**
1	00:00	00:15	
2	00:15	00:30	
3	00:30	00:45	
4	00:45	01:00	
5	01:00	01:15	
6	01:15	01:30	
7	01:30	01:45	
8	01:45	02:00	
9	02:00	02:15	
10	02:15	02:30	
11	02:30	02:45	
12	02:45	03:00	
13	03:00	03:15	
14	03:15	03:30	
15	03:30	03:45	
16	03:45	04:00	
17	04:00	04:15	
18	04:15	04:30	
19	04:30	04:45	
20	04:45	05:00	
21	05:00	05:15	
22	05:15	05:30	
23	05:30	05:45	
24	05:45	06:00	
25	06:00	06:15	
26	06:15	06:30	
27	06:30	06:45	
28	06:45	07:00	
29	07:00	07:15	
30	07:15	07:30	
31	07:30	07:45	
32	07:45	08:00	
33	08:00	08:15	
34	08:15	08:30	

35	08:30	08:45	
36	08:45	09:00	
37	09:00	09:15	
38	09:15	09:30	
39	09:30	09:45	
40	09:45	10:00	
41	10:00	10:15	
42	10:15	10:30	
43	10:30	10:45	
44	10:45	11:00	
45	11:00	11:15	
46	11:15	11:30	
47	11:30	11:45	
48	11:45	12:00	
49	12:00	12:15	
50	12:15	12:30	
51	12:30	12:45	
52	12:45	13:00	
53	13:00	13:15	
54	13:15	13:30	
55	13:30	13:45	
56	13:45	14:00	
57	14:00	14:15	
58	14:15	14:30	
59	14:30	14:45	
60	14:45	15:00	
61	15:00	15:15	
62	15:15	15:30	
63	15:30	15:45	
64	15:45	16:00	
65	16:00	16:15	
66	16:15	16:30	
67	16:30	16:45	
68	16:45	17:00	
69	17:00	17:15	
70	17:15	17:30	
71	17:30	17:45	
72	17:45	18:00	
73	18:00	18:15	
74	18:15	18:30	
75	18:30	18:45	
76	18:45	19:00	
77	19:00	19:15	
78	19:15	19:30	

79	19:30	19:45	
80	19:45	20:00	
81	20:00	20:15	
82	20:15	20:30	
83	20:30	20:45	
84	20:45	21:00	
85	21:00	21:15	
86	21:15	21:30	
87	21:30	21:45	
88	21:45	22:00	
89	22:00	22:15	
90	22:15	22:30	
91	22:30	22:45	
92	22:45	23:00	
93	23:00	23:15	
94	23:15	23:30	
95	23:30	23:45	
96	23:45	00:00	
Total In Mus			

Signature & Name:
(In-Charge Scheduling)

16.7 Time frame for Submissions

Time	Particulars of information	From	To	Form No.
By 1000 hrs.	Ex-power plant MW and MWh capabilities on 15 minute block basis for the next day	Respective generating stations & IPPs	SCC Manager	Format-A
By 1200 hrs.	MW and MWh energy availability for next day	SCC	Licensee	Format-B
By 1330 hrs.	Drawl requisitions by Licensee for the next day.	Licensee	SCC	Format-C

16.8 Format-D

Demand Forecast

Date of Submission:
Time of Submission

Name of distribution Licensees/ Licensee			
Sl. No.	**Month**	**Maximum Demand (MWh)**	**Minimum Demand (MWh)**
1	**January**		
2	**February**		
3	**March**		
4	**April**		
5	**May**		
6	**June**		
7	**July**		
8	**August**		
9	**September**		
10	**October**		
11	**November**		
12	**December**		
Total (MWh)			

Signature & Name:
(In-Charge Scheduling)

16.9 Format-E1

Generating Station Ex-bus Declared Capacity (Thermal)

Revision No._____

		Peak Hours	Off-Peak Hours
Name of Generating Station		Operational Capacity / Declared Capacity (MW)	
Schedule for date		Date of Submission	
Installed-Name Plate Capacity (MW)		Time of Submission	
Derated Capacity (MW)			

Reason for Non-Available Capacity for Peak and Off Peak Hour:* _____

*Reason for Non-Availability to be provided with Water Management Directives

Block No.	Block Time		Unit No.1		Unit No.2		Unit No.3								Total	
			MW	MWh	MW	MWh	MW	MWh							MW	MWh
1	00:00	00:15														
2	00:15	00:30														
3	00:30	00:45														
4	00:45	01:00														
5	01:00	01:15														
6	01:15	01:30														
7	01:30	01:45														
8	01:45	02:00														
9	02:00	02:15														
10	02:15	02:30														
11	02:30	02:45														
12	02:45	03:00														
13	03:00	03:15														
14	03:15	03:30														
15	03:30	03:45														
16	03:45	04:00														
17	04:00	04:15														
18	04:15	04:30														
19	04:30	04:45														
20	04:45	05:00														
21	05:00	05:15														
22	05:15	05:30														
23	05:30	05:45														
24	05:45	06:00														
25	06:00	06:15														
26	06:15	06:30														
27	06:30	06:45														
28	06:45	07:00														
29	07:00	07:15														
30	07:15	07:30														
31	07:30	07:45														
32	07:45	08:00														
33	08:00	08:15														
34	08:15	08:30														
35	08:30	08:45														
36	08:45	09:00														
37	09:00	09:15														
38	09:15	09:30														
39	09:30	09:45														
40	09:45	10:00														
41	10:00	10:15														
42	10:15	10:30														
43	10:30	10:45														
44	10:45	11:00														
45	11:00	11:15														
46	11:15	11:30														
47	11:30	11:45														

48	11:45	12:00														
49	12:00	12:15														
50	12:15	12:30														
51	12:30	12:45														
52	12:45	13:00														
53	13:00	13:15														
54	13:15	13:30														
55	13:30	13:45														
56	13:45	14:00														
57	14:00	14:15														
58	14:15	14:30														
59	14:30	14:45														
60	14:45	15:00														
61	15:00	15:15														
62	15:15	15:30														
63	15:30	15:45														
64	15:45	16:00														
65	16:00	16:15														
66	16:15	16:30														
67	16:30	16:45														
68	16:45	17:00														
69	17:00	17:15														
70	17:15	17:30														
71	17:30	17:45														
72	17:45	18:00														
73	18:00	18:15														
74	18:15	18:30														
75	18:30	18:45														
76	18:45	19:00														
77	19:00	19:15														
78	19:15	19:30														
79	19:30	19:45														
80	19:45	20:00														
81	20:00	20:15														
82	20:15	20:30														
83	20:30	20:45														
84	20:45	21:00														
85	21:00	21:15														
86	21:15	21:30														
87	21:30	21:45														
88	21:45	22:00														
89	22:00	22:15														
90	22:15	22:30														
91	22:30	22:45														
92	22:45	23:00														
93	23:00	23:15														
94	23:15	23:30														
95	23:30	23:45														
96	23:45	00:00														
Total (In Mus)																

Signature & Name:

(In-Charge Scheduling)

16.10 Format-E2

Generating Station Ex-bus Declared Capacity (Hydro)

Revision No._____

Name of Generating Station			Operational Capacity / Declared Capacity (MW)	Peak	Off-Peak
Schedule for date			Storage (m3)	Maximum	Minimum
Installed-Name Plate Capacity (MW)			Turbine inflow and outflow (m3/s)	Inflow	Outflow
Derated Capacity (MW)			Reservoir Level (m)	Maximum	Minimum

Block No.	Block Time		Unit No.1		Unit No. 2		Total	
			Plant Name		Plant Name		Plant Name	
			MW	MWh	MW	MWh	MW	MWh
1	00:00	00:15						
2	00:15	00:30						
3	00:30	00:45						
4	00:45	01:00						
5	01:00	01:15						
6	01:15	01:30						
7	01:30	01:45						
8	01:45	02:00						
9	02:00	02:15						
10	02:15	02:30						
11	02:30	02:45						
12	02:45	03:00						
13	03:00	03:15						
14	03:15	03:30						
15	03:30	03:45						
16	03:45	04:00						
17	04:00	04:15						
18	04:15	04:30						
19	04:30	04:45						
20	04:45	05:00						
21	05:00	05:15						
22	05:15	05:30						
23	05:30	05:45						
24	05:45	06:00						
25	06:00	06:15						
26	06:15	06:30						
27	06:30	06:45						
28	06:45	07:00						
29	07:00	07:15						

30	07:15	07:30						
31	07:30	07:45						
32	07:45	08:00						
33	08:00	08:15						
34	08:15	08:30						
35	08:30	08:45						
36	08:45	09:00						
37	09:00	09:15						
38	09:15	09:30						
39	09:30	09:45						
40	09:45	10:00						
41	10:00	10:15						
42	10:15	10:30						
43	10:30	10:45						
44	10:45	11:00						
45	11:00	11:15						
46	11:15	11:30						
47	11:30	11:45						
48	11:45	12:00						
49	12:00	12:15						
50	12:15	12:30						
51	12:30	12:45						
52	12:45	13:00						
53	13:00	13:15						
54	13:15	13:30						
55	13:30	13:45						
56	13:45	14:00						
57	14:00	14:15						
58	14:15	14:30						
59	14:30	14:45						
60	14:45	15:00						
61	15:00	15:15						
62	15:15	15:30						
63	15:30	15:45						
64	15:45	16:00						
65	16:00	16:15						
66	16:15	16:30						
67	16:30	16:45						
68	16:45	17:00						
69	17:00	17:15						
70	17:15	17:30						
71	17:30	17:45						
72	17:45	18:00						
73	18:00	18:15						
74	18:15	18:30						
75	18:30	18:45						

76	18:45	19:00						
77	19:00	19:15						
78	19:15	19:30						
79	19:30	19:45						
80	19:45	20:00						
81	20:00	20:15						
82	20:15	20:30						
83	20:30	20:45						
84	20:45	21:00						
85	21:00	21:15						
86	21:15	21:30						
87	21:30	21:45						
88	21:45	22:00						
89	22:00	22:15						
90	22:15	22:30						
91	22:30	22:45						
92	22:45	23:00						
93	23:00	23:15						
94	23:15	23:30						
95	23:30	23:45						
96	23:45	00:00						
Total (In Mus)								

Reason for Non-Available Capacity for Peak and Off Peak Hour:* _____

*Reason for Non-Availability to be provided with Water Management Directives

Signature & Name:

(In-Charge Scheduling)

16.11 Format -E3

Licensee Drawal Schedule

Revision No._____

Date of Submission:
Time of Submission

Name of distribution Licensees/ Licensee			
Schedule for date			
Block No.	Block Time		Total Drawal (MWh)
1	00:00	00:15	
2	00:15	00:30	
3	00:30	00:45	
4	00:45	01:00	
5	01:00	01:15	
6	01:15	01:30	
7	01:30	01:45	
8	01:45	02:00	
9	02:00	02:15	
10	02:15	02:30	
11	02:30	02:45	
12	02:45	03:00	
13	03:00	03:15	
14	03:15	03:30	
15	03:30	03:45	
16	03:45	04:00	
17	04:00	04:15	
18	04:15	04:30	
19	04:30	04:45	
20	04:45	05:00	
21	05:00	05:15	
22	05:15	05:30	
23	05:30	05:45	
24	05:45	06:00	
25	06:00	06:15	
26	06:15	06:30	
27	06:30	06:45	
28	06:45	07:00	
29	07:00	07:15	
30	07:15	07:30	
31	07:30	07:45	
32	07:45	08:00	
33	08:00	08:15	
34	08:15	08:30	

35	08:30	08:45	
36	08:45	09:00	
37	09:00	09:15	
38	09:15	09:30	
39	09:30	09:45	
40	09:45	10:00	
41	10:00	10:15	
42	10:15	10:30	
43	10:30	10:45	
44	10:45	11:00	
45	11:00	11:15	
46	11:15	11:30	
47	11:30	11:45	
48	11:45	12:00	
49	12:00	12:15	
50	12:15	12:30	
51	12:30	12:45	
52	12:45	13:00	
53	13:00	13:15	
54	13:15	13:30	
55	13:30	13:45	
56	13:45	14:00	
57	14:00	14:15	
58	14:15	14:30	
59	14:30	14:45	
60	14:45	15:00	
61	15:00	15:15	
62	15:15	15:30	
63	15:30	15:45	
64	15:45	16:00	
65	16:00	16:15	
66	16:15	16:30	
67	16:30	16:45	
68	16:45	17:00	
69	17:00	17:15	
70	17:15	17:30	
71	17:30	17:45	
72	17:45	18:00	
73	18:00	18:15	
74	18:15	18:30	
75	18:30	18:45	
76	18:45	19:00	
77	19:00	19:15	
78	19:15	19:30	

79	19:30	19:45	
80	19:45	20:00	
81	20:00	20:15	
82	20:15	20:30	
83	20:30	20:45	
84	20:45	21:00	
85	21:00	21:15	
86	21:15	21:30	
87	21:30	21:45	
88	21:45	22:00	
89	22:00	22:15	
90	22:15	22:30	
91	22:30	22:45	
92	22:45	23:00	
93	23:00	23:15	
94	23:15	23:30	
95	23:30	23:45	
96	23:45	00:00	
Total In Mus			

Signature & Name:
(In-Charge Scheduling)

16.12 Format -F

Daily report for actual energy injection by generator and projected energy injection with variance analysis

Month:_____

Name of Generating Station	
Type of Generating Station	Thermal/Hydro/Gas
Day of the Month	

Block No.	Block Time		Actual	Projected	Error(%)
			MWh	MWh	MWh
1	00:00	00:15			
2	00:15	00:30			
3	00:30	00:45			
4	00:45	01:00			
5	01:00	01:15			
6	01:15	01:30			
7	01:30	01:45			
8	01:45	02:00			
9	02:00	02:15			
10	02:15	02:30			
11	02:30	02:45			
12	02:45	03:00			
13	03:00	03:15			
14	03:15	03:30			
15	03:30	03:45			
16	03:45	04:00			
17	04:00	04:15			
18	04:15	04:30			
19	04:30	04:45			
20	04:45	05:00			
21	05:00	05:15			
22	05:15	05:30			
23	05:30	05:45			
24	05:45	06:00			
25	06:00	06:15			
26	06:15	06:30			
27	06:30	06:45			
28	06:45	07:00			
29	07:00	07:15			
30	07:15	07:30			
31	07:30	07:45			
32	07:45	08:00			
33	08:00	08:15			

34	08:15	08:30			
35	08:30	08:45			
36	08:45	09:00			
37	09:00	09:15			
38	09:15	09:30			
39	09:30	09:45			
40	09:45	10:00			
41	10:00	10:15			
42	10:15	10:30			
43	10:30	10:45			
44	10:45	11:00			
45	11:00	11:15			
46	11:15	11:30			
47	11:30	11:45			
48	11:45	12:00			
49	12:00	12:15			
50	12:15	12:30			
51	12:30	12:45			
52	12:45	13:00			
53	13:00	13:15			
54	13:15	13:30			
55	13:30	13:45			
56	13:45	14:00			
57	14:00	14:15			
58	14:15	14:30			
59	14:30	14:45			
60	14:45	15:00			
61	15:00	15:15			
62	15:15	15:30			
63	15:30	15:45			
64	15:45	16:00			
65	16:00	16:15			
66	16:15	16:30			
67	16:30	16:45			
68	16:45	17:00			
69	17:00	17:15			
70	17:15	17:30			
71	17:30	17:45			
72	17:45	18:00			
73	18:00	18:15			
74	18:15	18:30			
75	18:30	18:45			
76	18:45	19:00			
77	19:00	19:15			

78	19:15	19:30			
79	19:30	19:45			
80	19:45	20:00			
81	20:00	20:15			
82	20:15	20:30			
83	20:30	20:45			
84	20:45	21:00			
85	21:00	21:15			
86	21:15	21:30			
87	21:30	21:45			
88	21:45	22:00			
89	22:00	22:15			
90	22:15	22:30			
91	22:30	22:45			
92	22:45	23:00			
93	23:00	23:15			
94	23:15	23:30			
95	23:30	23:45			
96	23:45	00:00			
Total (In Mus)					

Notes: Reasons for variance to be assigned here

1

2

3

Signature & Name :

(In-charge Scheduling)

16.13 Format -G

Daily report for actual energy drawal by licensee and projected energy drawal with variance analysis

Month:_____

Name of Licensee	
Day of the Month	

Block No.	Block Time		Actual	Projected	Error(%)
			MWh	MWh	MWh
1	00:00	00:15			
2	00:15	00:30			
3	00:30	00:45			
4	00:45	01:00			
5	01:00	01:15			
6	01:15	01:30			
7	01:30	01:45			
8	01:45	02:00			
9	02:00	02:15			
10	02:15	02:30			
11	02:30	02:45			
12	02:45	03:00			
13	03:00	03:15			
14	03:15	03:30			
15	03:30	03:45			
16	03:45	04:00			
17	04:00	04:15			
18	04:15	04:30			
19	04:30	04:45			
20	04:45	05:00			
21	05:00	05:15			
22	05:15	05:30			
23	05:30	05:45			
24	05:45	06:00			
25	06:00	06:15			
26	06:15	06:30			
27	06:30	06:45			
28	06:45	07:00			
29	07:00	07:15			
30	07:15	07:30			
31	07:30	07:45			
32	07:45	08:00			
33	08:00	08:15			
34	08:15	08:30			
35	08:30	08:45			

36	08:45	09:00			
37	09:00	09:15			
38	09:15	09:30			
39	09:30	09:45			
40	09:45	10:00			
41	10:00	10:15			
42	10:15	10:30			
43	10:30	10:45			
44	10:45	11:00			
45	11:00	11:15			
46	11:15	11:30			
47	11:30	11:45			
48	11:45	12:00			
49	12:00	12:15			
50	12:15	12:30			
51	12:30	12:45			
52	12:45	13:00			
53	13:00	13:15			
54	13:15	13:30			
55	13:30	13:45			
56	13:45	14:00			
57	14:00	14:15			
58	14:15	14:30			
59	14:30	14:45			
60	14:45	15:00			
61	15:00	15:15			
62	15:15	15:30			
63	15:30	15:45			
64	15:45	16:00			
65	16:00	16:15			
66	16:15	16:30			
67	16:30	16:45			
68	16:45	17:00			
69	17:00	17:15			
70	17:15	17:30			
71	17:30	17:45			
72	17:45	18:00			
73	18:00	18:15			
74	18:15	18:30			
75	18:30	18:45			
76	18:45	19:00			
77	19:00	19:15			
78	19:15	19:30			
79	19:30	19:45			

80	19:45	20:00			
81	20:00	20:15			
82	20:15	20:30			
83	20:30	20:45			
84	20:45	21:00			
85	21:00	21:15			
86	21:15	21:30			
87	21:30	21:45			
88	21:45	22:00			
89	22:00	22:15			
90	22:15	22:30			
91	22:30	22:45			
92	22:45	23:00			
93	23:00	23:15			
94	23:15	23:30			
95	23:30	23:45			
96	23:45	00:00			
Total (In Mus)					

Notes: Reasons for variance to be assigned here

1

2

3

Signature & Name:

(In-Charge Scheduling)

16.14 Format-H1

Summary Report for Generation Forecast v Actual

Year:_____

Name of Generating Station:_____ Installed Capacity: _____MW

Type of Generating Station: _____ Annual PAF: _____

Generation Forecast Error	Actual Energy Generated (MWH)	Projected Energy Generation (MWH)	Error (%)		
			Avg	Dry	Wet
January					
February					
March					
April					
May					
June					
July					
August					
September					
October					
November					
December					
Annual Error					

Signature & Name :

(In-Charge Scheduling)

16.15 Format-H2

Summary Report for Energy Drawal Forecast v Actual

Year:_____

Name of Licensee:_____

Area of Operation: _____

Drawal Forecast Error	Actual Energy Drawal (MWH)	Projected Energy Drawal (MWH)	Error (%)		
			Avg	Dry	Wet
January					
February					
March					
April					
May					
June					
July					
August					
September					
October					
November					
December					
Annual Error					

Signature & Name:

(In-Charge Scheduling)

Deloitte.

Deloitte Touche Tohmatsu India Private Limited (U74140MH199 5PTC093339), a private company limited by shares, was converted into Deloitte Touche Tohmatsu India LLP, a limited liability partnership (LLP Identification No. AAE-8458), with effect from October 1, 2015.